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# USSR Report

ELECTRONICS AND ELECTRICAL ENGINEERING

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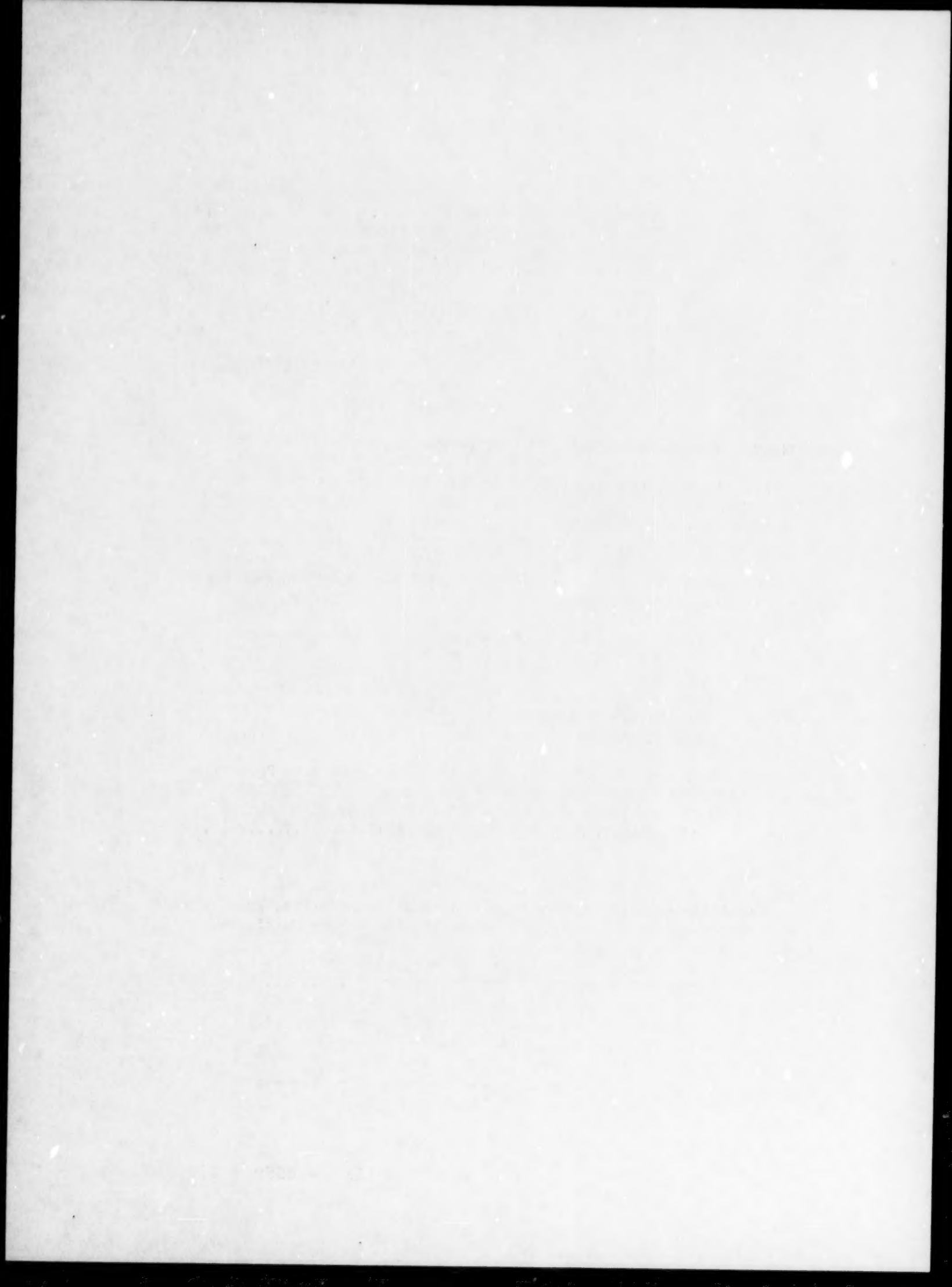
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24 October 1985

# USSR REPORT

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EXPERIMENTAL VALIDATION OF MODEL OF LATENT IMAGES IN ELECTRORESIST

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 6 Mar 84) pp 118-123

DERKACH, V. P., KORSUNSKIY, V. M., STARIKOVA, L. V. and KURBATSKEYA, N. P.,  
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[Abstract] An experiment has been designed for verifying a theoretical model of latent images in electroresist layers after exposure to electron-beam treatment and before development. The model is based on the distribution of energy release or the concentration of radiative-chemical transformations which are hardly measurable in small regions of micron or sub-micron dimensions. In order to maximally suppress the effect of development, it is necessary to use thin electroresist layers and develop them so that the edge of the emerging image will always correspond to the same threshold concentration of radiative-chemical transformations. The irradiation threshold density will then be the minimum density at which the threshold concentration of transformations reaches the center of the image. Comparison of computed constant-concentration lines with actually developed image contours is possible on this basis. Experimental verification of the accuracy of such a model involves the use of test diagrams with rectangular figures of widely varying sizes and proportions, sufficiently far apart for separate exposure, also hollow rectangles with nonexposable inside areas and individual stripes as well as stripe bundles. Images are produced by exposure of these test diagrams to an electron beam less than 0.05  $\mu\text{m}$  in diameter, in a ZRM-12 machine with an accelerating voltage of 30 kV. After development, the images are viewed and photographed under a Neophot optical microscope. Taking into account inevitable calculation and experimental errors as well as the diversity of figures on a test diagram, the agreement between the theoretical model and the experimental verification was found to be satisfactory so that the computer calculation program can be regarded as adequate. The authors thank I. F. Kazo for assistance in making exposures. Figures 5; tables 1; references 14: 8 Russian, 5 Western.  
[258-2415]

## DEPENDENCE OF SENSITIVITY AND CONTRAST CHARACTERIZING POSITIVE RESISTS ON DEVELOPMENT PARAMETERS AND ON DEPTHWISE ABSORPTION PROFILE

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 13 Mar 84) pp 124-129

GOLIKOV, B. I., Institute of Solid-State Physics, USSR Academy of Sciences

[Abstract] The performance of polymer layers as positive resists is analyzed, the characteristic feature of this class of resist materials being the breakup of their macromolecules under bombardment by high-energy rays or particles. A polymer layer of given thickness on a substrate is considered under bombardment by X-rays or electrons with subsequent dissolution in a developer. The dependence of sensitivity and contrast on the depthwise profile of absorbed dose and on the development characteristics is calculated, assuming that the absorption profile is  $\epsilon(z) = \mu I e^{-\mu z}$  in the case of X-rays and

$$\epsilon(z) = \frac{I}{R_G} (0.74 + 4.7\xi - 8.9\xi^2 + 3.5\xi^3) \text{ in the case of electrons (z- depth,}$$

I- surface exposure dose,  $\mu$ - absorption coefficient,  $R_G = AE^{1.75}/\rho - Gr\ln$  radius, E- energy of electrons,  $\rho$ - density of the materials,  $\xi = z/R_G$ , A- constant). The resulting relations and numerical data pertaining to polymethyl methacrylate and a 1:3 mixture of methyl isobutyl ketone and isopropanol indicate that the lithographical characteristics of resist-developer pairs, those on which the dissolution rate depends, determine the resist performance parameters. The author thanks V. V. Aristov for valuable comments.

Figures 2; references: 13 Western.

[258-2415]

## SURFACE PASSIVATION OF SEMICONDUCTOR CIRCUIT ELEMENTS WITH LAYER OF WIDEBAND SEMICONDUCTOR

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 15 May 84) pp 140-143

SYSOYEV, B. I., BEZRYADIN, N. N., DRONOV, A. S. and ROVINSKIY, A. P.

[Abstract] Protective surface passivation of semiconductor elements for circuit integration was studied experimentally on Al-SiO<sub>2</sub>-ZnP<sub>2</sub>-Si structures and evaluated theoretically on the basis of the MOS\*S-structure model. Specimens for this study were built on n-Si and p-Si single crystals with high electrical resistivity ( $\rho \approx 7.75 \text{ ohm}\cdot\text{cm}$ ) and with orientation in the  $\langle 111 \rangle$  plane or the  $\langle 100 \rangle$  plane. Layers of  $\beta$ -ZnP<sub>2</sub> were deposited by vacuum evaporation to various thicknesses of 0.1-1.2  $\mu\text{m}$ . After a rinse of the Si



wafers according to standard silicon IC technology, 0.1-0.3  $\mu\text{m}$  thick  $\text{SiO}_2$  layers were deposited by high-frequency sputtering. Data on charge redistribution in the  $\text{ZnP}_2$ -Si system were obtained by measurement of high-frequency capacitance-voltage characteristics, 1 MHz having been empirically found to be the most suitable test frequency. The results reveal that the capacitance of structures on high-resistivity silicon depends on both the magnitude and the sign of  $dV/dt$ , unlike the capacitance of structures on strongly doped low-resistivity ( $\rho \sim 0.01 \text{ ohm}\cdot\text{cm}$ ) silicon, this dependence being related to modulation of the space-charge region in the Si substrate. The state of this space-charge region in an Al- $\text{SiO}_2$ - $\text{ZnP}_2$ -Si structure almost corresponds to the state of flat energy bands. With a thin  $\text{ZnP}$  sublayer ( $d < 0.4 \mu\text{m}$ ), this space-charge region is controlled even by a  $dV/dt < 10^{-2} \text{ V/s}$ . With a thick  $\text{ZnP}_2$  sublayer ( $d > 2L_{\text{Debye}}$ ), on the other hand, the charge in the  $\text{SiO}_2$  layer has almost no influence on the state of the space-charge region in the Si layer. Therefore, a sufficiently thick  $\text{ZnP}_2$  sublayer ( $d > 0.7 \mu\text{m}$ ) ensures a voltage-independent capacitance of the structure approximately corresponding to the state of flat energy bands in Si. Figures 2; references 15: 9 Russian, 6 Western (2 in Russian translation).  
[258-2415]

UDC 621.382.2/3

#### CHARACTERISTICS OF ELECTROPHYSICAL AND PHOTOELECTRIC PROPERTIES OF MOS-STRUCTURES ON INDIUM ARSENIDE

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 8 Dec 83) pp 134-139

LOSKUTOVA, Ye. A., DAVYDOV, V. N. and LEZINA, T. D., Siberian Institute of Engineering Physics

[Abstract] An experimental study was made of MOS-structures on InAs, for a thorough exploration of their electrophysical and photoelectric characteristics. Specimens for this study were prepared from n-InAs single crystals with a [111] orientation and a donor concentration of  $1.6 \cdot 10^{16} \text{ cm}^{-3}$ . Their chemico-mechanically and mechanically polished surfaces were oxidized galvanostatically in a 20% solution of orthophosphoric acid on ethylene glycol with an anodizing current density of  $1 \text{ A/cm}^2$ , until a 0.1  $\mu\text{m}$  thick anodic oxide film characterized by a breakdown voltage of 40-50 V and a leakage current of  $10^{-10} \text{ A/cm}^2$  had built up. A semitransparent nickel electrode was deposited by vacuum evaporation. The capacitance-voltage characteristics were measured by the frequency-divider method at 1 MHz, with no capacitance dispersion found over the 300 kHz - 10 MHz range. The photo-emf was measured with a light-activated diode at the 0.95  $\mu\text{m}$  wavelength and a 70 Hz modulation frequency. The data obtained include voltage of the flat energy bands and hysteresis of the capacitance-voltage characteristic on both positive and negative halves of the voltage sweep ( $-14 \text{ V} \rightarrow 0 \rightarrow +14 \text{ V}$ ) at a constant reverse bias ( $-5 \text{ V}$ ), spectrum of surface states and voltage dependence of the small-signal photo-emf over the -10-(-2) V range at various voltage sweep rates, also dependence of the photo-emf on the frequency of radiation intensity modulation at various field-electrode voltages and temperature dependence of the photo-emf under weak



and strong inversion of the InAs surface. The results reveal strong interaction of states and free carriers in the anodic oxide layer and at its boundary with the InAs layer, activation of traps, especially hole traps, by a negative voltage, and a critical voltage sweep rate lower than 0.2 V/s and thus much lower than theoretical ( $10^{-10}$  V/s) corresponding to transition from equilibrium below it to nonequilibrium above it. An analysis of the results indicates that these characteristics of InAs-MOS structures depend not only on the voltage sweep rate and the frequency of radiation intensity modulation but also on the effects of an electric field and its polarity, in accordance with the Shockley-Reed-Hall mechanism of generation and recombination. Figures 4; references 14: 9 Russian, 5 Western.  
[258-2415]

PREDICTING AND DIAGNOSING PERFORMANCE OF TRANSISTORS, INTEGRATED CIRCUITS AND LARGE-SCALE-INTEGRATION SYSTEMS BY MULTILEVEL SIMULATION METHODS AND PROGRAMS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 30 Mar 84) pp 3-7

BUBENNIKOV, A. N., MITYASHEV, B. N. and SADOVNIKOV, A. D.

[Abstract] Application of multilevel simulation methods and programs to discrete transistors as well as to integrated circuits and large-scale-integration systems is considered, for effective performance and reliability evaluation on the basis of technological, physico-topological, or componential models. In order to predict and diagnose the behavior of such devices, it is necessary to determine the sensitivity of electrical characteristics on design, structural and fabrication factors. The most important factors are increase of the perimeter-to-area ratio of the emitter, adequately high doping levels in all three emitter-base-collector regions, and moderately high collector-junction breakdown voltage. Multilevel simulation by the method of informative parameters makes it possible to estimate relative increases of the surface-recombination component of the base current, relative increases of the peripheral minority-carrier injection current, effects of high doping and injection levels, and effects of low collector-junction breakdown voltage of thin-film semiconductor structures. A procedure on the basis of a physico-topological model using TRAN 1, TRAN 1.5, TRAN 2 programs for current-voltage characteristics, recombination and injection currents, total base and collector currents, has been applied to three transistor structures built by similar IZOPLANAR topological routing. The two fundamental sets of equations in this model are those relating the electron current and the hole current to the respective surface-recombination ratios and those relating the electrostatic surface potential to the surface charge density, with the appropriate boundary conditions everywhere. Calculations according to this procedure reveal where LSI transistor structures differ appreciably from analogous IC and MSI (medium-scale-integration) transistor structures. This is demonstrated on the static transfer characteristic of an ECL (emitter-coupled logic) element of an LSI structure for 0.45 V logic difference with 3 mW power drain under a set of  $n = 3$  loads at typical ambient and operating temperatures. Figures 6; tables 1; references 4: 3 Russian, 1 Western.  
[259-2415]

## NONSINUSOIDAL MODES OF OSCILLATOR WITH MULTIFREQUENCY SURFACE-ACOUSTIC-WAVE RESONATOR

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 3 May 83) pp 604-611

GUREVICH, G. L., ZHIZHENKOVA, L. N., PASHKIN, V. M. and SPASYUK, A. M.

[Abstract] Quartz resonators for stabilization of oscillators are being replaced by SAW resonators, because the latter can operate at higher frequencies with the same high stability and are technologically more advantageous. A multifrequency SAW resonator is considered as means of producing tunable monochromatic signals for such applications as frequency synthesizers and multistate memories. Such a resonator is also capable of producing simultaneous oscillations at several frequencies resulting in a modulated and thus nonsinusoidal output signal. Such a resonator is formed by a pair of interdigital electroacoustic transducers with a highly inductive load each, to ensure a high reflection coefficient, and with feedback through a unidirectional amplifier between them for compensation of losses. Its performance is analyzed on the basis of the admittance matrix which relates currents and voltages in the equivalent electric circuit. Steady state and transients are included in the general analysis. A particular mode of operation is switching single-frequency operation from one frequency to another by momentary modulation of oscillator parameters at a frequency equal to the difference between adjacent resonator frequencies. This is not feasible with small amplitude modulation, but is feasible with sufficiently wide amplitude modulation. It is also feasible with modulation of the load reactance, resulting in phase modulation. For easier demonstration of the principle, the feedback amplifier is removed and an active device such as a tunnel diode is connected across one of the transducers. The frequency switching process was simulated on a BESM-6 high-speed computer. It was also studied in an experiment with external modulation of the load and with a varicap as controllable element, with the distance between transducers  $L = 312\lambda$  ( $\lambda$  - wavelength of sound), and with 200 MHz as the center frequency. Figures 4; references: 6 Russian.  
[307-2415]

## AMPLITUDE-TIME CHARACTERISTICS IN SYSTEMS EMPLOYING INERTIAL PHOTODETECTORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian, No 4, Apr 85,  
(manuscript received 7 Apr 83), pp 10-11

SHEMSHEDINOV, R. B.

[Abstract] The amplitude-time characteristics of the signals output by the detecting devices are analyzed considering the inertia of the input circuit and the correlation of the noise at the inputs of the signal amplifier. The analysis assumes optimal linear filtering of a pulse signal; a formula is derived for the signal output by the photodetector. It is found that the amplitude of the output signals drops as the inertia of the photodetecting circuit and the amplifier noise increase. It is shown that the output signals will always be symmetrical for optimal filtering if symmetrical pulses are input. Even slight deviations from optimal filtering will result in significant asymmetry of the output signals. The findings are helpful for optimizing the parameters of various optical-electronic devices. Figures 1; references: 7 Russian.  
[301-6900]

## NOISE CHARACTERISTICS OF STROBOSCOPIC TRANSDUCERS BUILT WITH GaAs MICROCIRCUIT INTEGRATION

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 6 Apr 84) pp 162-168

STAROSELSKIY, V. I.

[Abstract] Stroboscopic transducers are used for measuring electric signals over a wide frequency range, the sensitivity of these devices being largely determined by the equivalent input noise voltage. The internal noise level can be appreciably lowered and the performance of such a transducer correspondingly improved by GaAs microcircuit integration of the input stage. A chip of  $1 \times 1 \text{ mm}^2$  area can carry a mixer bridge of four Schottky-barrier diodes, a storing capacitor with discharge circuit, and a voltage repeater on Schottky-gate field-effect transistors, shot noise in the mixer diodes, and flicker noise in the diodes as well as in the voltage repeater. Two noise mechanisms are identified, corresponding to the two modes of transducer operation: mixer noise alone during strobing, mixer noise with noise in the discharge circuit and in the voltage repeater during measurement of widened pulses. The resultant spectral noise density is calculated on the basis of these identifications and corresponding equivalent circuit diagrams. During strobing the flicker noise appears as a multiplicative component and its deviation from the  $1/\omega$  law determines its lower frequency limit. During measurement of a widened pulse the noise is



limited to the pass band of the output amplifier-integrator stage and a low-pass filter before this stage becomes desirable. It is possible to minimize the noise in either mode of operation by optimizing the pass band of the amplifier-integrator, the design parameters of the capacitor discharge circuit, the transfer characteristic of the mixer, and the topology of the field-effect transistor in the voltage repeater. Shot noise and flicker noise decrease as the integration time in the output stage is shortened, thermal noise decreases to infinitesimal levels in a capacitor discharge circuit with a switch which has a low resistance when open and diodes which have a high reverse resistance when the switch is closed. Figures 3; tables 1; references: 5 Russian. [258-2415]

UDC 621.382

# STRUCTURAL TRANSFORMATIONS IN SEMICONDUCTORS DURING OPTICAL PUMPING

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 6 Jun 84) pp 153-161

KOPAYEV, Yu. V., MENYAYLENKO, V. V. and MOLOTKOV, S. N., Institute of Physics and Institute of Solid-State Physics, USSR Academy of Sciences

[Abstract] Phase transformations in  $A^{IV}B^{VI}$  semiconductors which occur during irradiation by a laser beam are analyzed on the basis of a theoretical model with the electron energy-band spectrum in the zeroth-order approximation and with the coupling in p-orbitals assumed to be strong, a characteristic feature of  $A^{IV}B^{VI}$  semiconductors being their deviation from stoichiometry and a consequently high doping level. Instability of their cubic lattice stems from the behavior of the Fermi surface in the hypothetical metallic initial phase. Distortion of the cubic lattice is accounted for by the phase potential. With the difference between A and B atoms disregarded, the electron spectrum corresponds to three one-dimensional half-filled energy bands. Nonequivalence of A and B atoms is then taken into account by introduction of the ionicity potential. A measure of the laser pumping power is the total number of excited quasi-particles. Calculations beginning with the Hamiltonian in the Bloch-functions basis and assuming a dominance of nonthermal effects during phase transformations, followed by replacement of summation with integration with respect to energy, lead to a system of equations which has five possible solutions with different symmetry each: 1) rhombohedral symmetry with diagonal shift of sublattices; 2) triclinic symmetry with charge carriers filling only the  $p_z$  band; 3) triclinic symmetry with charge carriers filling both  $p_x$  and  $p_y$  bands; 4) rhombic symmetry with shift of sublattices in (110) direction; 5) tetragonal symmetry with shift of sublattices in (001) direction. Dependence of the energy gap on the ionicity level and on the doping level is established, whereupon the dependence of the energy gap on the pumping power is found to be unique at ionicity levels below critical and ambiguous at ionicity levels above critical. Laser pumping evidently weakens the effect of doping. The phase diagram



thus depends correspondingly on the pumping level and the doping level. As the doping level or the ionicity level degenerates to zero, the characteristics of the material correspond to those of group-V elements (Bi, Sb, As) or of  $\text{Bi}_{1-x}\text{Sb}_x$  alloys respectively. An analysis of the phonon spectra and phonon instability reveals certain analogies with the silicon lattice and diamond lattice. The authors thank B. A. Volkov and V. V. Kapayev for discussions. Figures 4; references 22: 12 Russian, 10 Western (1 in Russian translation). [258-2415]

UDC 621.317.18

#### METHODOLOGY FOR DETERMINING DYNAMIC CHARACTERISTICS OF TRISTABLE-LOGIC INTEGRATED CIRCUITS

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 27 Mar 83) pp 169-170

PASHAYEV, A. M. and ADZHALOV, A. R., Institute of Physics, AzSSR Academy of Sciences

[Abstract] The problem of determining the dynamic characteristics of integrated-circuit transistor-transistor logic with three stable states is considered. The third state besides logic "1" and logic "0" is a high-impedance open-circuit state equivalent to that of a relay with normally open contact. Measurement of the dynamic characteristics in this state is very difficult, even with automatic or semiautomatic instruments, because the INHIBIT potential of an input pulse cannot be established with sufficient accuracy. There has therefore been proposed determination by prediction on the basis of a set of output parameters, using analytical relations between electrical parameters along with functional relations as well as correlations between parameters of the integrated circuit and those of its components. In tests, moreover, one will use statistical distributions of integrated-circuit parameters. According to this methodology, within prescribed tolerances on easily measurable dynamic parameters in the resolving state, one can calculate other parameters such as the signal-propagation delay time with a guaranteed probability of 0.9937 according to the "three sigma" rule. Figures 1; references: 3 Russian. [258-2415]

## REDUCING DYNAMIC ERRORS OF INTEGRATED-CIRCUIT CMOS SWITCHES

Moscow MIKROELEKTRONIKA in Russian Vol 14, No 2, Mar-Apr 85  
(manuscript received 7 Jan 84) pp 178-179

DANILOV, A. A. and POLONNIKOV, D. Ye., Institute of Control Problems, USSR Academy of Sciences

[Abstract] Analog CMOS switches and commutators such as those of series 590 and 591 feature high open-state resistance, low and nonlinear conducting-state resistance, low residual voltage, bidirectionality, potential coupling between switch or commutator circuit and control circuit, high speed, and voltage as well as current switching capability. Their major drawbacks are high interference level and long transient period, high input and output capacitances, high temperature coefficient of resistance and appreciable open-circuit leakage current. An analysis of an inverter-controlled CMOS transistor pair reveals that interference signals generated by passage of the control-voltage pulsefront through the gate-channel capacitances in the two complementary transistors, successively, do not compensate one another but add up. At the same time, the main cause of a slow output signal transient are transients in the control circuit which prolong the rise time of the control-voltage pulse. The oscillatory transient with overshoots travels through the gates to the channels, subsequently appearing across the switch resistance and thus prolonging the output signal transient. As a remedy is proposed a special circuit for shaping the control voltage pulse into a maximally square one. One version of such a circuit consists of an input current switch on two Schottky-barrier diodes and an unsaturated differential stage on a pair of bipolar transistors with low collector-base capacitance. With one of the two diodes under any condition inherently closed, interference mixing with the control signal is effectively suppressed and current stabilization at the output of this switch proceeds almost ideally. This circuit and its operation are designed so that neither of the two transistors ever saturates. With this special circuit, the commutation interference in CMOS switches built with series K176LP1 integrated-circuit chips was reduced to below 100 mV and the output signal transient reduced to an aperiodic one. Figures 2; references: 3 Russian.  
[258-2415]

## COMMUNICATIONS

UDC 621.396.22:621.371.332.1

### RELIABILITY OF TWO-WAY COMMUNICATION OVER RADIO LINE WITH POWER REGULATION

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after abridgment, 6 Jul 84) pp 8-9

ONYSHKO, A. G. and POSTYUSHKOV, V. P.

[Abstract] The reliability of two-way radio communication is analyzed, considering that it's transmission quality criteria must be satisfied simultaneously in both directions. The effect of crosstalk in a duplex radio line is evaluated accordingly, in terms of the signal-to-interference ratio and the power transmission coefficient. For a channel with a log normal distribution of fadeout, moreover, it is demonstrated that the effect of interference and thus the loss of reliability can be effectively reduced by means of additive power regulation at the sender end.

Figures 2; references: 1 Russian.  
[259-2415]

UDC 621.396.962

### QUANTIZATION NOISE DURING DIGITAL PROCESSING OF SIGNALS BY METHOD OF HARMONIC ANALYSIS IN RADIO COMMUNICATION LINE WITH SYNTHESIZED ANTENNA APERTURE

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after abridgment, 3 Sep 84) pp 10-12

SAZONOV, N. A.

[Abstract] A radio communication line with synthesized antenna aperture and with digital processing of signals is considered, digital processing by the method of harmonic analysis being effected according to the FFT (fast Fourier transformation) algorithm. Besides quantization noise generated during multiplication of signals by the reference function and during calculation of the signal spectrum in the FFT device there is also noise caused by inaccuracy of the Fourier coefficients and by overflow of a

register with fixed decimal point, overflow being avoidable by a scaling down of signals. The quantization noise, in terms of the mean output noise power, is estimated by the method of mathematical induction with thin-out of the FFT either in the time domain or in the Frequency domain. The signal-to-noise ratio is found to be maximizable with the aid of a rectangular weight function. Numerical calculations, aided by graphical representation, reveal that the output signal-to-noise ratio depends on the quantization noise more strongly as the dispersion of the input noise decreases. Stepwise scaling down the signals improves the output signal-to-noise ratio appreciably, but without it there is also a certain number of readings called the FFT case which yields the maximum signal-to-noise ratio for any given word length. Figures 2; references 5: 1 Russian, 4 Western (3 in Russian translation). [259-2415]

UDC 621.396.62:621.391.84

# ATTENUATION OF SUSCEPTIBILITY TO INTERFERENCE IN COMBINATION-FREQUENCY CHANNELS OF INFRADYNE RECEIVER

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 3 Jul 84) pp 25-26

SARAYEV, S. M.

[Abstract] Prediscrimination is considered as a method of increasing the interference immunity of infradyne receivers, instead of maximally widening the dynamic range of the amplifier-mixer stages and adaptive reception control. Owing to its selectivity, a prediscriminator attenuates the susceptibility to interference at a combination frequency, aided by the lower transmission coefficient of the mixer at intermediate frequencies equal to combination frequencies  $f_c = \pm n f_s \pm m f_h$  ( $f_s$  - signal frequency,

$f_h$  - heterodyne frequency,  $n$  and  $m$  integers denoting orders of harmonics), when the channel frequency differs from the frequency  $f_0$  to which the receiver has been tuned. This is demonstrated by an analysis of combination frequencies in the plane of  $f_c/f_h, f_s/f_h$  coordinates. Since a tunable prediscriminator impairs the tunability of a receiver, it is preferable to use a fixed one with a bandwidth equal to the tuning range or subrange. Effective use of a prediscriminator therefore requires selecting the proper intermediate frequency and, in the case of a wideband fixed one, limiting the width of the receiver tuning range or subrange. The intermediate frequency should be selected to match the highest-order signal harmonic which forms an attenuable combination-frequency channel and to match the slopes of the prediscriminator amplitude-frequency characteristic. This intermediate frequency will accordingly be higher for a receiver with sum-frequency mixer than for one with difference-frequency mixer. References 8: 7 Russian, 1 Western. [259-2415]



## STATISTICAL CHARACTERISTICS OF SPECTRA OF RANDOM PHASE-KEYED SIGNALS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 18 Jun 84) pp 47-50

GUTIN, V. S.

[Abstract] Sequences of random phase-keyed signals are characterized by the spectrum of their complex envelope  $G(\alpha) = S(\alpha)H(\alpha)$  ( $\alpha = 2\pi f\tau_0$ ,  $f$  - frequency or repetition rate,  $\tau_0$  - duration of a sequence element,  $S(\alpha)$  - spectrum of an elementary pulse,  $H(\alpha)$  - spectrum of code sequence) and by the energy spectrum  $Z(\alpha) = |H(\alpha)|^2$  of the code sequence. The mean value  $\bar{Z}(\alpha) = N$  and the dispersion  $D_Z(\alpha)$  of the energy spectrum are calculated for three binary code sequences on the basis of their algebraic properties. They are the  $N = 7$  Barker code  $+++--+$  and two arbitrary  $N = 7$  codes  $++---+$ ,  $+-++-$ . The stability of these energy spectra with respect to changes in the signal structure is characterized by the ratio  $C_Z(\alpha) = \sigma_Z(\alpha)/\bar{Z}(\alpha)$  of the mean-square deviation  $\sigma_Z(\alpha) = \sqrt{D_Z(\alpha)}$  to the mean value. On the basis of these relations are plotted the dependence of the normalized energy spectrum  $Z/N$  and of the stability factor  $C_Z$  on  $f\tau_0$ , the latter for not only  $N = 7$  but also for

$N = 4, 13, 100$ . Furthermore are calculated the number  $P_n$  of sequences containing  $n$  "-1" elements, this number being equal to the number of combinations  $C_N^n$  "N into n" as function of  $Z_n(0)$  and the spectrum distribution  $p(Z)$  as function of  $Z$ . Figures 4; references: 7 Russian.  
[259-2415]

## ESTIMATING CARRIER FREQUENCY OF NARROW-BAND RADIO SIGNAL

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 18 Jun 84) pp 50-53

GALUN, S. A. and ZHUKOVSKAYA, T. A.

[Abstract] The carrier frequency  $f_0$  of narrow-band radio signals in radar or satellite communication systems is measured assuming that such a signal has the form  $s(t; f_0, F_0, \phi_0) = \alpha[\sin(\pi F_0 t)/(\pi F_0 t)] \cos(2\pi f_0 t - \phi_0)$ . When the initial phase  $\phi_0$  and the frequency band  $F_0$  are not known or not exactly known, a band estimation channel is added to the carrier-frequency measuring instrument. Interference in this channel reduces the accuracy of band estimation, which in turn reduces the accuracy of carrier-frequency measurement. In the case of a signal mixed with additive noise  $x(t) = s(t; f_0, F_0, \phi_0) + n(t)$  the solution to the corresponding boundary-value problem for the Fokker-Planck-Kolmogorov equation yields both bias and scatter of the carrier-frequency estimate as functions of the signal-to-noise ratio, neither



the method of a small parameter nor the Rao-Kramer bound being adequate here because of nondifferentiability of the readings statistics with probability  $P = 1$  at any magnitude of the band estimation error. The scatter of a reliable carrier-frequency reading, normalized to the frequency band squared, has been plotted as function of the signal-to-noise ratio for several key values of the relative band estimation error  $e$  ( $-0.1, -0.5, 0, +0.1, +0.5$ ). The  $e = 0$  line, representing the ideal case, is the limiting one which all the others approach asymptotically. Figures 1; references 6: 5 Russian, 1 Western.  
[259-2415]

UDC 621.615

#### OPTIMUM FREQUENCY OF COMMUNICATION CHANNEL FOR INDOOR RADIO TELEMETRY

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 31 May 84) pp 70-73

KVITKA, A. A., PODLEPETSKIY, B. I. and CHERNYSHEVA, S. D.

[Abstract] A major problem in application of radiotelemetry to biological research and medical practice is indoor interference caused by superposition of forward and reflected waves, with resulting signal fadeout. Avoidance of this effect requires that the radio transmitter operate at the optimum signal wavelength and the radio receiver be placed in the optimum location. A method of determining both is proposed on the basis of an experimental study and a theoretical model. Measurements were made with the Prima radiotelemetric system developed and built by A. A. Kvitka with others and a V6-1 selective microvoltmeter, in an  $8 \times 5 \times 3.5$  m<sup>3</sup> large room where the radio receiver was placed successively in three different locations (first in corner 0,0,0 m, then closer to the center 2.5,1.5,1.0 m and 1.25,0.75,1.0 m) while the radio transmitter on a dielectric post was moved around in 0.25 m steps successively in three horizontal planes 1, 1.5, 2 m respectively above the floor. Measurements were made at eight frequencies (60, 30, 20, 15, 12, 10, 8.89, 7.5 MHz). The mathematical model, for a parallelepipedic room, is based on five assumptions: 1) lossless propagation of electromagnetic waves so that forward and reflected waves have equal amplitudes; 2) invariable modulus of electric field vector upon reflection by walls, as if walls were ideal conductors; 3) 180° phase shift upon reflection; 4) radio transmitter simulated as a point source, length of its antenna being much smaller than signal wavelength; 5) only single reflections considered, multiple reflections disregarded. Calculations according to this model agree closely with the experimental data and, therefore, can be used for determining the signal wavelength or communication channel frequency at which there will be no fadeout with the receiver in any location. Then, placing the receiver in or near the middle of the room will minimize the optimum wavelength and thus maximize the energy efficiency of the system. Figures 2; references: 6 Russian.  
[259-2415]

## CLASSIFICATION OF DETERMINISTIC SIGNALS UNDER CONDITIONS OF INTERFERENCE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 19 Mar 84) pp 520-523

ASATURYAN, V. I.

[Abstract] The problem of classifying  $k$  deterministic signals in the presence of interference is solved on the basis of linear unbiased estimators of signal parameters. An additive mixture of signal and interference is considered, the vector of its readings  $Y_1$  and the vector of unknown parameters  $b_1$  at successive instants of time satisfying the conditions  $M(Y_1) = X_1 b_1$  and  $D(Y_1) = \sigma_1^2 I_{N_1}$  ( $M(Y_1)$  - mathematical expectation

of vector  $Y_1$ ,  $D(Y_1)$  - covariance matrix of vector  $Y_1$ ,  $X_1$  - vector of known parameters,  $\sigma_1^2$  - unknown dispersion,  $I_{N_1}$  - unit matrix of order  $N_1$ ). The

problem is solved accordingly for two deterministic signals ( $1 = 1, 2$ ) for which  $\sigma_1^2 = \sigma_2^2 = \sigma^2$  and  $X_1 \neq X_2$ , with rank  $X_1 = r_1 < p$  and thus incomplete.

The procedure involves reducing the two models of incomplete rank  $X = r < p$  to one of complete rank  $X = p$ , based on the definition of a verifiable hypothesis with six lemmas and one corollary. The procedure is demonstrated on the example of  $p = 4$  ( $p_0 = 8$ ) and an arbitrary  $3 \times N_1$ -dimensional third-rank matrix  $X_1^0$  ( $1 = 1, 2$ ). References 8: 7 Russian, 1 Western (in Russian translation).

[307-2415]

## VECTOR MINIMIZATION OF NO-SIGNAL DECISION PROBABILITIES IN TWO-SIGNAL DISCRIMINATION PROBLEM

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 16 May 83) pp 486-493

KUKERAYEV, A. M. and SINDLER, Yu. B.

[Abstract] The problem of optimal reception on the basis of discrimination between signals with an erasure zone is solved, specifically for two signals, by two procedures which simultaneously minimize the probabilities of no-signal decisions for both signals. Each procedure involves determining the randomized resolvent vector-function as criterion, equal to either 1 or 0 depending on the relative magnitudes of the probability densities of the measured  $n$ -dimensional vector in the presence of each signal alone. In the first procedure the two probabilities of mistaking one signal for the other

are constrained by respective upper bounds. This procedure is effective for either continuous or discrete distributions. In the second procedure the resolvent vector-function minimizes the corresponding Lagrange functional. This procedure is effective for continuous distributions only, but it is simpler and yields more convenient estimators of no-signal decision probabilities. A typical application is noncoherent detection of a pulse signal with Rayleigh amplitude fluctuations submerged in white noise. Figures 4; references 6: 4 Russian, 2 Western (both in Russian translation).  
[307-2415]

UDC 621.396.946.2:621.39

#### MAIN TRENDS IN SATELLITE COMMUNICATION AND BROADCASTING RESEARCH

Moscow ELEKTROSVYAZ in Russian No 5, May 85  
(manuscript received 19 Feb 85) pp 15-18

ZUBAREV, Yu. B. and KANTOR, L. Ya.

[Abstract] The main advantages of satellite communication systems are possibility of multiple-call communication over a wide geographical zone, multistation access to a common satellite trunk resulting in a high utilization factor, formation of direct channels between any ground stations, commutation of floating channels in the time domain according to demand, and elimination of the distance between ground stations as a factor influencing the channel quality and cost. Satellite communication systems also have physically inherent drawbacks, namely a long signal delay of up to 300 ms in geostationary or Molniya systems, a Doppler frequency shift of up to  $\pm 10^{-8}$  in a geostationary orbit or up to  $\pm 10^{-5}$  in an elliptical orbit, and predictable short interruptions caused by solar effects on the antennas of ground stations or during necessary switching from one satellite to another. With the advantages well established and the drawbacks taken into consideration, a major effort is underway to fit satellite communication into the Unified Automatic Communication Network. One promising development is television broadcasting via satellite, which requires a channel within the 12 GHz frequency band and a narrow beam so as to facilitate broadcasting of republic-wide programs and reception of more nationwide programs within any given broadcast zone where no more channels within the Ekran, Moskva, Orbita frequency bands are available. Another promising development of two-way satellite communication with "pencil" beams within the 11-14 GHz. A third possibility is newsprint telecasting via satellite, now done over television channels from the Moskva station or by Orbita and Orbita-RV systems. Satellite communication systems can significantly contribute to sound broadcasting, also to a higher transmission speed requiring interference-immune coding matched with multipositional modulation. An important role in further development of satellite communication systems will be played by computer and microprocessor-aided monitoring and adaptation of ground stations under changeable channel conditions as well as by application of computer and microprocessor techniques to construction and

standardization of satellite channel equipment. Figures 2;  
references 6: 5 Russian, 1 Western.  
[308-2415]

UDC 621.396.22.029.7

TRANSMISSION OF TELEVISION SIGNALS OVER OPTICAL COMMUNICATION CHANNEL BY  
MEANS OF FREQUENCY MODULATION

Moscow ELEKTROSVYAZ in Russian No 5, May 85  
(manuscript received 5 Jun 84) pp 28-30

KIRIK, Yu. M., KRIVOSHEYEV, M. I., MARIMONT, Yu. I., KHARITONOVA, Yu. A.,  
SHLAYN, A. I. and SHCHERBAKOV, Ye. A.

[Abstract] Frequency modulation is considered as means of transmitting television signals over fiber-optic communication channels, because this method remains viable in nonlinear channels and retains a high signal-to-noise ratio even at a high modulation index. Its advantage over pulse-rate modulation, also an effective method for this application, is that a much narrower frequency band suffices and no special modem equipment needs to be installed. The signal-to-noise ratio is in this case defined as the ratio of image signal voltage squared to weighted noise signal squared. It is calculated here accordingly, at the subcarrier frequency, for a receiver channel with an avalanche photodiode as current source or with a p-i-n photodiode as a special case with unity mean avalanche multiplication factor. An experimental verification was made with a 32DL103 semiconductor laser emitting radiation at the 0.85  $\mu$ m wavelength and a 0-60 dB adjustable light intensity attenuator on the transmitter side. On the receiver side was used a germanium or silicon photodiode and an intermediate-frequency pre-amplifier in a common housing, the first stage of the preamplifier built on a field-effect transistor with an input impedance of 400 ohms resistive after compensation of the input capacitance by a circuit with a 30 MHz bandwidth at the 70 MHz center frequency. The rest of the equipment was standard hardware. The results confirm the feasibility and the advantages of using frequency modulation for transmission of television signals over fiber-optic lines. Figures 2; references 5: 1 Russian, 4 Western.  
[308-2415]



## RESONATORLESS COAXIAL DEVICE FOR ADDITION OF TWO HIGH-POWER SIGNALS

Moscow ELEKTROSVYAZ in Russian No 5, May 85

(manuscript received 25 Apr 84 pp 37-40)

ANTONENKO, V. M., BERLYAVSKIY, I. Z., MODEL', A. M. and POSADSKAYA, L. A.

[Abstract] A resonatorless coaxial device for addition of two signals has been developed which consists of three directional couplers acting as bridges, two semireflecting structures, segments of a coaxial line, and a ballast load. The directional couplers are made of coupled strip lines and have a 3 dB crosstalk attenuation, with the external high-frequency connector wires extended inside the housing through fingers in the latter. Each of the semireflectors is a strip line segment shaped into a spiral and connected at each end to a coaxial line segment with capacitive beads as inhomogeneities. Such a design results in size reduction, while use of aluminum as conductor material contributes to a weight reduction. Short-circuited strip line segments of approximately  $1/2 \lambda_0$  length (wavelength  $\lambda_0$  corresponds to the center frequency  $f_0 = 1/2(f_{10} + f_{20})$ , where  $f_{10}$  and  $f_{20}$  are the center frequencies of the two added signals) at the ends of the strip line acting as ballast load maintain the coaxiality of outer and inner spiral conductors when the inner conductor is lengthened. With a VSWR = 1.05, the device has a power rating of 2 kW. The bridge design was developed by V. I. Chubis. Figures 7; references: 4 Russian. [308-2415]

UDC 621.396.677

## MEASUREMENT OF CROSS-POLARIZATIONAL RADIATION PATTERNS OF PENCIL-BEAM REFLECTOR ANTENNAS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 13 Jul 84) pp 40-41

BUZUYEV, Yu. B. and NEPOMNYASHCHIY, I. L.

[Abstract] Measurement of the radiation patterns of antennas operating in multitrunk radio relay arrays is essential for the purpose of ensuring maximum cross-polarizational decoupling, especially in the case of pencil-beam antennas. While a reference radio transmitter with a high-gain antenna is needed for reliable readings, measurement of cross-polarization patterns requires a special filter transparent only to radio waves in one linear polarization mode and such a filter is difficult to construct for an antenna with large aperture. This complication due to conflicting requirements can be avoided by mutual alignment of the test antenna and the reference antenna with respect to the  $E_{01}$ -mode. Following an alignment for the maximum received signal, the  $E_{01}$ -mode exciter is placed at the output of the signal source and both antennas are trimmed, by rotation through small



angles only, for the minimum received signal. With the antennas in their final positions, corresponding to a minimum signal level 50-60 dB below the maximum one, cross-polarization patterns of the test antenna in a vertically polarized field and in a horizontally polarized field are measured with respectively horizontal and vertical polarization of the field radiated by the antenna of the radio reference. Figures 3; references: 3 Russian. [308-2415]

UDC 621.394

#### LONG-HOURS OPTIMIZATION OF COMMUNICATION TRAFFIC ROUTING BY MEANS OF TWO-WAY AND ONE-WAY CHANNELS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 5 Dec 83) pp 47-51

VRAZHNOV, V. N.

[Abstract] A method of optimizing the traffic routing between two stations in an automatic communication network is proposed, the two stations being connected through two bundles of one-way channels (one bundle in each direction) and one bundle of two-way channels into which traffic from any of the two one-way bundles can be diverted. The method involves determining the optimum ratio of the number of one-way channels to the number of two-way channels for the minimum total cost of all three bundles. This optimization is based on distributions of incoming and outgoing loads at each station over a 24 h period, which covers staggered peak hours in each direction, an alternating Poisson distribution of load intensity and a hyperexponential distribution of time intervals between calls. The corresponding problem of discrete minimization under inequality-type constraints and discretization constraint is solved through matching of the one-way bundle capacities so as to ensure the prescribed service quality at any time during a given period of day or night. The target function, after having been selected, is evaluated by the method of equivalent substitutions with only the first two moments of the load distribution needing to be considered for a sufficiently close approximation. The target function must be a unimodal but not necessarily differentiable one. The algorithm of the solution can be simplified to eight steps, including evaluation of the target function with the aid of Laplace-Stieltjes transformation and recurrence relations. The algorithm has been programmed for a computer so as to be directly usable for design of specific telephone and telegraph networks. Figures 2; references 12: 9 Russian, 3 Western. [308-2415]

## MAGNETIC AUTOMATION ATTACHMENT FOR TELEGRAPH APPARATUS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 30 May 84)  
pp 51-54

TERENTYEV, B. P., NIKOL'SKIY, S. G., NIKOLAYEV, A. Yu. and TRIFONOV, Yu. A

[Abstract] A magnetic automation attachment is considered as replacement for existing mechanical transmitter and reperforator attachments, the main drawbacks of the latter being inadequate mechanical strength and low reliability, limited reusability of information carriers, laborious error correction and editing procedures, noisiness, and clogging by "garbage". The magnetic attachment must be adaptable to both present electromechanical telegraph apparatus and future electronic telegraph apparatus. It can tap into the connection between the line terminal of the ringing device and the subscriber line, or into the connector joining the electronic telegraph modules, or into the connection between the electromechanical telegraph apparatus and the ringing device. Technical specifications have been developed and formalized for the purpose of ensuring satisfactory operation of the entire equipment. The basic five components of the magnetic attachment are a power supply, a drive, a set of heads, a recording-playback unit, and an encoder-decoder. The encoder-decoder provides the interface between the recording-playback unit and a direct-access of buffer direct-access memory. Three different schemes of interconnection with the other equipment have been considered and designed. Figures 4; references 6: 2 Russian, 1 Hungarian, 3 Western.

[308-2415]

## BICRITERIAL PROBLEM OF DATABASE OPTIMIZATION FOR AUTOMATIC TELEGRAM INDEXING SYSTEM

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 10 Oct 83)  
pp 55-56

KANAYAN, S. N. and MATEVOSYAN, N. P.

[Abstract] A mathematical model is constructed for optimum assignment of telegram indexing data in a computer memory, such a database having generally three file levels and being searched by multilevel sorting methods. The optimization problem is solved for a bicriterial target function characterizing the specific case of data stored on magnetic disks for distribution between a direct-access memory and an external memory. The problem is reduced to integer programming with Boolean variables. References 4: 3 Russian, 1 Western.

[308-2415]

## CLASS OF FINITE SIGNALS NOT GENERATING TRANSIENTS IN LINEAR CHANNELS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 13 Jul 83)  
pp 57-60

YEGOROV, E. S. and KLYUYEV, V. I.

[Abstract] A class of finite signals is considered for effective suppression of intersymbol interference in data transmission systems, as an alternative to correcting the amplitude-frequency and phase-frequency characteristics of channels. Unlike discrete finite signals which retain their duration but not their waveform upon passage through a linear narrow-band channel, these signals must not suffer an energy loss so that the signal-to-noise ratio at the receiver input will not drop and they become suitable for use with frequency division of channels. An analysis of the channel response to signals with discrete amplitude modulation (idle pause) or phase modulation ( $180^\circ$  shift) of the general form

$$x(t) = \sum_{i=0}^{\infty} (\alpha_i \cos \omega_i t + b_i \sin \omega_i t) \quad (0 \leq t \leq T, \quad i = 1 \frac{2\pi}{T})$$

or

$$x(t) = \int_0^{\infty} [\alpha(\omega) \cos \omega t + b(\omega) \sin \omega t] d\omega \quad (0 \leq t \leq T)$$

indicates that they will satisfy those requirements if they do not generate transients in a linear channel, for which it is necessary and sufficient that their mirror image  $x(-t)$  ( $0 \leq t \leq T$ ) be an orthogonal function of each component of the channel pulse response on the  $0 \leq t \leq T$  interval. Signals in this class can be designed with the appropriate weight factors to yield a nearly maximum attainable band utilization factor for channels with various pulse response characteristics such as, typically

$$g(t) = 2\alpha \frac{\omega_0}{\beta} e^{-\alpha t} \sin \beta t$$

( $t \geq 0$ ,  $\beta^2 = \omega_0^2 - \alpha^2$ ) denoting the natural frequency and

$\frac{2\alpha}{\omega_0}$  denoting the attenuation coefficient) or that of a Butterworth filter,

also for channels with slowly varying parameters but finite number of states. Figures 1; references 5: 4 Russian, 1 Western.

[308-2415]

## ESTIMATING COVARIANCE FUNCTION ON BASIS OF REALIZATION WITH THINNED OUT SAMPLE

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 29 Aug 84)  
pp 60-62

NIKOLAYEV, V. T. and TALYZIN, V. N.

[Abstract] A method is proposed for estimating the covariance function of two random processes, namely using thinned out samples where the discretization frequency for one of the processes can be selected arbitrarily low for any prescribed estimation accuracy. The validity of this method is demonstrated by an analysis of the statistical characteristics of any two stationary and stationarily coupled processes as well as of those of the sought estimate, dependent on the sample size and the corresponding average. It is shown that the error caused by sample thinning can be compensated by lengthening the realization of the two processes, decreasing the mean-square deviation of the covariance function by a factor  $q$  requiring that the realization be lengthened by a factor  $q^2$ . The only practical limitation on the length of realization is the finite stationarity interval of any process. The validity of this method extends to the general case where the readings in the realizations of two processes  $\{x(t_j)\}$  and  $\{y(t_j)\}$  are describable by the functions  $f_{1,2} = 1$  without thinning at  $t_j$  and  $f_{1,2} = 0$  with thinning at  $t_j$ . The method reduces appreciably the number of readings to be analyzed for estimation of the covariance function. Figures 1; references: 3 Western (all in Russian translation).  
[308-2415]

INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY HELD IN TOKYO

Moscow ELEKTROSVYAZ in Russian No 5, May 85 pp 44-46

BORONICHEV, G. K., KAPITONOV, V. V. and LIPATOV, V. V.

[Abstract] The first international symposium on electromagnetic compatibility was held in October 1984 in Japan, with the participation of scientists and engineers from other Asian countries as well as from Africa and Latin America. The symposium was broken down into 25 work groups dealing with control of electromagnetic interference and compatibility parameters, noise, electromagnetic sensors and antennas, radio interference, electromagnetic compatibility in mobile communication services, sensitivity of radioelectronic equipment, electromagnetic pulse and electrostatic discharge and their simulation, biological effects of electromagnetic energy, radio interference measurements, electromagnetic interference and compatibility in instruments and other equipment, propagation of radio interference, shielding against and absorption of electromagnetic energy, filtration and processing of signals, reflection and scattering of signals, lightning sources, standards and measurements pertaining to electromagnetic compatibility, electromagnetic compatibility in communication systems, electromagnetic coupling and pickup, and electromagnetic facilities. A total of 184 papers was presented, and subsequently published in the transactions. They fall into three groups dealing respectively with theoretical analyses, experimental studies, and instrumentation for measurements. Particularly interesting developments were reported on TEM-mode cells, V/UHF antennas, feederless antenna test systems, quasi-peak detection, and models of electromagnetic fields in humans and animals. References: 27 Western (including Japanese). [308-2415]



UDC 53.08:681.3

APPARATUS FOR EXPERIMENTAL STUDY OF HIGH-RESOLUTION RADIOMETERS AND THEIR CHARACTERISTICS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 26 Jan 84) pp 33-35

AFONIN, A. V., ZAKHARNEV, A. P. and MURAVYEVA, G. I.

[Abstract] A test stand has been developed and built for determining the characteristics of high-resolution optoelectronic instruments such as radiometers experimentally. Its main optical components are a collimator with a telephoto lens of 4544 mm focal length, for simulating an infinitely far object of 5" angular width. Optical fibers of a light collector-conductor are placed with their glowing exit apertures between the focal plane and the first optical surface of that lens so that their distance from the entrance pupil of a tested instrument can be simulated at a distance from 2.5 m to infinity. Other optical components include a lamp, a modulator followed by a condenser lens between the lamp and the entrance aperture of the fiber-optic bundle, two external point light sources, an objective which together with two fixed-and-scanning mirror pairs produces moving images of these sources, a luminaire, a shield, a photometric sphere with the luminance of its window controllable over the  $10^{-4}$ -250 cd/m<sup>2</sup> range, a light-splitter plate before the photometer window, and a light-activated diode operating in the pulse mode for measuring the transfer characteristics of the tested instrument. The data recording and processing system consists of an AI-4096 analyzer and a Nairi-K computer. The test stand was used for determining the pulse response characteristic of a scanning radiometer with a 40" wide field of vision and with a mirror-lens objective, at a scanning speed of 6°/s with a point source at a simulated distance of 36 m, also its both modulation and phase transfer characteristics. Figures 3; references: 3 Russian.  
[271-2415]

## FREQUENCY CHARACTERISTICS OF DIFFERENTIAL OPTRON

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85

(manuscript received, after abridgment, 17 Jul 84) pp 76-78

MAMEDOV, A. K.

[Abstract] A differential optron is used in optoelectronic amplifiers with the main optron pair in the feedthrough circuit for galvanic decoupling of stages and the auxiliary optron pair in the feedback circuit for stabilizing the characteristics of the main pair. Considering that the amplifier performance depends largely on how nearly identical the amplitude-frequency characteristics of both pairs are, these characteristics were measured in an experimental study with KOD301 differential optron amplifiers commercially produced in the Soviet Union. On the basis of these measurements has been established the dependence of the amplifier frequency characteristics on the difference between the amplitude-frequency characteristics of both optron pairs as well as on the photodiode impedance load of each light-emitting diode and on the latter's supply current. The nonidentity of both optron pairs was characterized by the frequency-dependent parameter

$$\delta = 1 - \frac{|K_m(1\omega)| / |K_a(1\omega)|}{K_m(0)/K_a(0)} \quad (|K_m(1\omega)|, |K_a(1\omega)| - \text{moduli of current transfer}$$

ratios of main pair and auxiliary pair respectively,  $K_m(0), K_a(0)$  - corresponding moduli at zero frequency) and by the relative difference of their cutoff frequencies  $\gamma = (f_{c,m} - f_{c,a})/f_{c,m}$ . According to the results  $\delta \leq 1\%$

at a cutoff frequency and  $\gamma \leq 5\%$  for these KOD301 optron pairs. The time constant at cutoff frequency, characterizing the intrinsic inertia of an optron pair, was measured with the light-emitting diode under small load (up to 1 kohm) and large bias current (5-10 mA) as well as under large load (1-10 kohm) and small bias current (1-5 mA), with the cutoff frequency changing correspondingly by up to 15%. So were also determined the parameters of the RC circuits consisting of the diode junction capacitances and the external circuit resistances, an important factor determining the dynamic characteristics of an optron pair. Figures 4; references: 2 Russian.

[259-2415]

## POWER SUPPLIES FOR ELECTROTECHNICAL EQUIPMENT AND OUTLOOK FOR THEIR DEVELOPMENT

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85 (manuscript received 18 Dec 84)  
pp 2-6

SVENCHANSKIY, A. D., doctor of technical sciences, professor, BORODACHEV, A. S., candidate of technical sciences, and BERSHITSKIY, M. D., engineer

[Abstract] Special power supplies for electrical engineering equipment came into use toward the end of the nineteen fifties, most large equipment such as electric-arc steelmaking and ore processing furnaces operating until then from 220 V or 380 V - 50 Hz a.c. power networks either directly with positional step regulation of the average power or through transformers or autotransformers with smooth regulation in special cases only. Since then there have been introduced d.c. power supplies, mainly for arc welding, and later frequency step-up converters for small induction, dielectric, crucible furnaces or other heat treatment apparatus. The rating of those power supplies was first rather low, ranging from tens to hundreds of kilo-voltamperes only, except for the 8-12 MVA electric-arc steelmaking and ore processing furnaces. Their rating has steadily increased, creating a demand for higher primary a.c. voltages and for large single-phase motor-generator sets. This in turn has given rise to problems associated with voltage and current waveform distortion in the primary a.c. networks as well as with asymmetric unbalanced loading of a 3-phase network. The need for stabilizing the operation of conventional as well as subsequently introduced modern electronic equipment such as plasma, electron-beam, and laser machines, also the need for fast and accurate regulation of this equipment have stimulated development of not only high-speed high-precision power supplies but also filter-type and dynamic compensators of reactive power for minimizing the detrimental effects of large electric furnaces on the primary a.c. network. A solution to the problems was found in the thyristor, a noninductive semiconductor power device. Its advantages as key element of a power supply are its high response speed characterized by time constant in the millisecond range, possibility of smooth and accurate controllability of its output voltage or current, structural compactness and absence of rotating parts with consequently low noise level, and high efficiency. In special cases where smooth voltage regulation is not essential, plain diodes are used for rectification of the primary a.c. voltage. Where the requirements are more severe, on the other hand, thyristor banks are competitively replaced by parametric power supplies with automatic load current stabilization within 1-2% or by a thyristor bank in combination with a capacitor bank as energy storing device in pulse power supplies for plasma, ion-beam, and laser machines. The continuing trend is toward higher unit power of electrical equipment and correspondingly lower-frequency static power supplies, with fine step-wise voltage regulation by the pulse-phase or, better yet, pulse-width method. This necessarily accompanied by steady improvement of the semiconductor technology, resulting in higher power ratings and better

performance characteristics of semiconductor devices, in the feasibility of higher-degree circuit integration of control modules, and in more readily installable energy-efficient and reliable power supplies. Tables 1; references: 2 Russian.  
[265-2415]

UDC 621.311.4

#### POWER SUPPLY FOR MAGNETRON-TYPE SPUTTERING EQUIPMENT

Moscow ELEKTROTEKHNIKA in Russian No 5, Mar 85  
(manuscript received 21 May 84) pp 11-13

VOLKOV, I. V., doctor of technical sciences, professor, GUBAREVICH, V. N., candidate of technical sciences, ALEKSANDROV, M. M., candidate of technical sciences, KABAN, V. P., candidate of technical sciences, and SPIRIN, V. M., candidate of technical sciences

[Abstract] Magnetrons are used for efficient generation of a dense plasma above the cathode-target surface, needed in the production of ultrathin transparent films for liquid crystals or of thin films of various metals ranging from aluminum and its alloys to chromium and refractory metals, also of various reinforcing, wear-resistant, protective, and decorative thin films. In order to ensure an efficient sputtering process, the power supply for such a magnetron must remain stable during high-frequency voltage oscillations caused by the plasma and current oscillations caused by arcing at the cathode surface. This requirement was taken into consideration in development and design of a magnetron sputtering system with overload immunity. A parametric current source containing inductive-capacitive converter used in voltage sources maintains a constant output current over a wide range of load impedance. Smooth regulation of the output power, however, requires that the characteristics of the power supply and the magnetron be matched under varying pressure or magnetic induction. Phase-by-phase addition of the currents of two parallel inductive-capacitive converter tank circuits has been found to be the optimum mode of operation, one converter being fixed and the other one regulating the current phase while stabilizing the current amplitude. The fixed converter consists of a 3-phase inductive-capacitive tank circuit. The controllable converter consists of an induction motor with a clamped rotor and with a 3-phase capacitor bank in series with the stator winding. This induction motor acts as phase regulator as well as inductance for the tank circuit. The resultant phase currents are rectified by a 3-phase diode bridge and the d.c. output current of the latter is controlled by signals from a power transducer in series with the rotor winding. Such a power supply has been found to have excellent technical and economic performance characteristics for production of less than 10 nm thick films with a magnetron-type sputtering machine. Smooth regulation of power between  $P_{\max} = \text{const}$  and  $P_{\min} = \text{const}$  levels is effected by means of a potentiometer. Figures 2; references: 5 Russian.  
[265-2415]



## CONTROL OF POWER SUPPLIES FOR INDUSTRIAL DIRECT-CURRENT PLASMATRONS

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 11 Jun 84) pp 13-15

KRUCHININ, A. M., doctor of technical sciences, and PESHEKHONOV, V. I.,  
engineer, Moscow Institute of Power Engineering

[Abstract] Power supplies for heavy-duty d.c. plasmatrons are usually built with controlled rectifiers and automatic arc-current regulation, or with semicontrolled rectifiers consisting of thyristors in one half of the 3-phase bridge and plain diodes in the other half. The advantages of semicontrolled rectifiers are higher power factor and lower cost, but they require a large inductance in the load circuit for current stabilization. Another possibility is combining a fixed high-voltage low-current source for intermittent starting and a controllable high-current low-voltage source for continuous running. The design of such a power supply is based on the fundamental first-order differential equation of arc energy  $dH/dt = i^2G - P_L$  ( $H$ - enthalpy,  $i$ - current,  $G$ - electrical conductance,  $P_L$ - power loss,  $t$ - time), which can be solved when the dependence of arc enthalpy and power loss on the arc conductance as well as the arc current as function of time are known. A power supply with automatic control has been designed on the basis of power-law approximations of arc enthalpy and power loss,  $H(G) = a_1 G^n + a_0$  and  $P_L(G) = b_1 G^m + b_0$ , for a cylindrical-equivalent plasma arc and laminar flow of the axial plasma layer. The equation of dynamics and the equation of the electric circuit for the arc voltage yield the structure of the control system, which is particularly simple in the case of proportional regulation. The design and performance analysis has been programmed in FORTRAN for a YeS 1033 computer, including the standard RKSG subroutine for solving differential equations. A comparative evaluation of various possible control structures for a 1 MW plasmatron on hydrogen with interelectrode inserts indicates that integral correction is most expedient, ensuring a stable arc for 3-6 min duration in  $10^{-5}$  s steps with a half as large smoothing choke coil as required in the case of proportional regulation. Figures 2; references: 4 Russian. [265-2415]



## ELECTRIC POWER SUPPLIES FOR PULSE LOADS WITH CONTROLLABLE CHARGING OF CAPACITIVE ENERGY STORING DEVICES

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 10 May 84) pp 15-19

BLUATOV, O. G., candidate of technical sciences, IVANOV, V. S., candidate of technical sciences, KRASAVIN, V. N., engineer, and PANFILOV, D. I., candidate of technical sciences

[Abstract] The capacitor charging process is evaluated from the standpoint of controllability under pulse loads and for design of the appropriate power supply. The basic component of a power supply for capacitive energy storing devices is a d.c.-d.c. voltage converter built with transistors. Fixed chargers with resistive or inductive current-shaping circuits for constant or oscillatory charging are inadequate under pulse loads. Controllable d.c. chargers with continuous regulation, pulse-time regulation, pulse-amplitude regulation using resistive current shapers, or with both pulse-amplitude and pulse-time regulation in a multistage arrangement are more suitable, as are possibly also combinations of controllable charger with pulse-time regulation and fixed charger for constant-power charging or otherwise optimum tradeoff. The design and performance evaluation of a basic converter operating at a frequency of 10 kHz for a charger with 1 kW average-power rating and a 10 Hz discharge pulse rate, built with KT908B switching and current-shaping transistors, KD213B high-voltage rectifying diodes, series OL laminations in the cores of transformers and series ShL laminations in the cores of inductive chokes, indicates that adaptive regulation algorithms become necessary for stabilization of either the charging current or the power when the load is a device such as the crystal of a solid-state pulse laser subject to temperature fluctuations with resulting fluctuations of the emission threshold. Figures 6; references: 8 Russian.  
[265-2415]

UDC 621.373.54:621.327:621.375.826

## HIGH-POWER SOURCES WITH SMOOTHLY ADJUSTABLE PULSE DURATION FOR POWERING GAS-DISCHARGE TUBES OF LASER PUMPING SYSTEMS

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 10 May 84) pp 19-20

VAKULENKO, V. M., candidate of technical sciences, IVANOV, L. P., engineer, GANSHIN, Yu. A., engineer, KARPYSHEV, I. L., engineer, and KORNEYEV, V. A., engineer

[Abstract] A series of power supplies for gas-discharge tubes in laser pumping systems has been developed on the basis of the same circuit but with

different levels of partial discharge of the capacitive energy storing device. The charger converts the a.c. network voltage into a constant current, very efficiently and at the same charging rate regardless of the discharge level. An overall size and weight reduction is made possible by an intermediate frequency conversion from 50 Hz to 1 kHz, which also allows raising the repetition rate of output pulses. The charger consists of an inverter and a rectifier. The parallel-type inverter includes a thyristor-diode bridge with capacitors and a transformer, and a choke coil, for converting the sine-wave a.c. network voltage into a higher-frequency (1 kHz) square-wave alternating one after first rectifying it. An important feature here is stiff overvoltage suppression, especially across the switching capacitors, during wide swings such as from no load to full load. The rectifier includes a 300/1000 V step-up transformer with another thyristor-diode bridge and a choke coil in series. A discharge commutator across the rectifier output shunted by a filter-capacitor ensures proper cutoff of the charge discharge current and corresponding control of the pulse duration. This commutator consists of a choke coil followed by a power thyristor in series and shunted by a transformer with blocking diodes for dumping excess energy. The secondary winding of the transformer taps between choke coil and power thyristor at one end and connects to a thyristor bridge with a capacitor in the diagonal at the other end. The three basic power supplies (two of them also in modified version with indicating device and with energy stabilization during every laser emission pulse) are rated for 1.6, 6.3, and 10 kW respectively, to be used with garnet lasers, generate pulses of 0.3-10/5/10 ms duration, 0.2-0.9/8/0.9 kV amplitude, and 0.1-4/2/4 kJ energy at repetition rates of 0.1-20/100/200 Hz. Figures 1; tables 1; references: 4 Russian. [265-2415]

UDC 621.373.5:621.375.826

# HIGH-POWER PULSE GENERATOR WITH PULSEFORM CONTROL FOR POWERING GAS-DISCHARGE TUBES OF LASER PUMPING SYSTEMS

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 10 May 84) pp 21-22

IVANOV, L. P., engineer

[Abstract] A power pulse generator with controllability of the pulseform as well as with regulation of the pulse amplitude, duration, and repetition rate is very desirable as a power supply for gas-discharge tubes of laser pumping systems. An outstanding example of such a generator is one which consists of split capacitive and inductive energy storing devices, with thyristors used for switching. The pulseform is varied by changing the connections between capacitive and inductive elements in the parallel-series grid and by regulation of the switching schedule. A typical generator consisting of five capacitors, seven thyristors (controlled rectifiers), four diodes (fixed rectifiers), and a choke coil can power a gas-discharge flash tube with a variety of pulses depending on the

particular application. A welding laser, for instance, requires a pulse which peaks early its leading edge and then drops to a lower level so as to maintain the melt at a constant temperature before it falls along its trailing edge. A piercing laser requires a pulse which peaks late so as to facilitate removal of the liquid phase of material from the hole, just before it falls along its trailing edge. A precision reaming laser requires a "packet" pulse which has several successive peaks between its leading and trailing edges. The model IPI-60 generator designed for solid-state lasers (garnet, ruby, glass) has two panels of six energy storing capacitors chargeable to 400 V each. It operates from a 220/380 V - 50 Hz a.c. network and discharges in pulses of up to 2000 V amplitude, up to 15 ms duration, and up to 1200 J energy with an average power of 10 kW at repetition rates of up to 200 Hz. The pulseform can be varied here smoothly, with either internal or external synchronization for timing the thyristor switches. Figures 2; references: 1 Russian. [265-2415]

UDC 538.945

#### RADIO-FREQUENCY SQUID OPERATING IN AUTODYNE MODE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 18 Nov 81) pp 596-603

GUSEV, A. V. and KRYANOV, V. A.

[Abstract] A new mode of operation is proposed for a fluxmeter using a SQUID with hysteresis and at a point beyond the first plateau of its characteristic. This operation, in the frequency-modulation mode, involves frequency coding with the fluxmeter circuit in the configuration of a self-excited oscillator. The performance of such a device is analyzed on the basis of its equivalent circuit diagram, with three noise sources added to the conventional radio-frequency components. One of these sources is thermal noise, the other two are noncorrelated other than thermal components of noise emf and current in the active element. Conventional circuit analysis yields, in the approximation of harmonic balance, the condition for FM operation. Evaluation of dynamic and fluctuation characteristics is based on a phenomenological model, one which includes current jumps beyond the plateau of the characteristic and their shift in time in the presence of signal and noise. The sensitivity of the instrument is determined in terms of the threshold signal level for the noise band. In the case of negligible noise the same sensitivity is attainable with frequency modulation beyond the plateau as with amplitude modulation on the plateau. In the case of appreciable noise, especially when it becomes dominant, there must be taken into account the dynamic reaction of the SQUID on the lead-in tank circuit and the resulting low-frequency fluctuation current in the SQUID ring. The authors thank V. N. Rudenko for formulation of the problem and O. V. Snergirev for helpful discussion. Figures 1; references 11: 8 Russian, 3 Western. [307-2415]

EXPERIMENTAL STUDY OF UNIDIRECTIONAL FERRITE MICROSTRIP LINES

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 16 May 84) pp 64-67

BOBROV, P. P., GIDLEVSKIY, A. V. and KIRSANOV, Yu. A.

[Abstract] An experimental study of unidirectional ferrite microstrip lines was made, for the purpose of determining their characteristic and input impedances as well as the effect of insertion of a lumped inhomogeneity on the unidirectional properties. The characteristic impedance was determined by comparison of a known lumped load impedance along the line with the input impedance near the free edge of the upper conductor, after measurement of the complex reflection coefficient as the ratio of output-to-input complex voltage amplitudes over the 1-3 GHz frequency range with a DK1-5 instrument and a 50 ohm standard S6-2A resistor (ceramic cylinder with absorbent coating layer of thickness equal to that of the ferrite substrate). The characteristic impedance was found to be low, within 3-5 ohms for the 60SCh ferrite material, and to thus limit the range of insertable amplifying or control elements. The data are useful for design optimization of rectifiers, circulators, attenuators, modulators and other nonreciprocal devices on microstrip lines. The input impedance of a lumped inhomogeneity inserted along the line to form a decimetric-wave circulator, for instance, was measured with the aid of a half-wavelength loop connected in parallel at the input end and tuned to a frequency higher than the center frequency of the circulator operating range so as to weaken the frequency dependence of that impedance. Considering the increase of losses in an edge wave upon insertion of a control element, the stability of such a wave in the presence of an inhomogeneity with very low impedance was established on the basis of insertion loss and phase shift measurements over the 1.9-2.3 GHz frequency range with the slug connected to the free edge of the upper conductor. The frequency range can be widened by placing the slug in the center hole. Figures 6; references 10: 7 Russian, 3 Western.  
[259-2415]



## MINIMUM-LENGTH QUASI-REGULAR SMOOTH TRANSITIONS FOR MICROSTRIP LINES

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85 pp 74-75

[Annotation of article No 490 deposited at Central Institute of Scientific and Technical Information 'Informsvyaz', 15 pp with 9 figures and 19 bibliographic references]

YASHIN, A. A.

[Abstract] Specific procedures for synthesis of matching transitions between microstrip lines of various types have been developed on the basis of a common approach, namely minimizing the length and maintaining a constant impedance, very promising in the design of microwave microelectronic devices with high level of integration. The types of transitions include widening of the current-carrying conductor of an asymmetric line and various lines to coplanar ones. The procedures are applicable to diffusion-epitaxial lines on semiconductor substrates with shield or with housing-shield in the monolithic type of integration. Their accuracy is within 2-5% when based on the quasi-T model. Figures 1; references: 3 Russian. [259-2415]

UDC 621.372.54

## ACTIVE BAND-PASS FILTER WITH ELLIPTIC AMPLITUDE-FREQUENCY CHARACTERISTIC

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 18 Jun 84) pp 86-87

KAPILEVICH, B. Yu. and SAFONOV, S. Yu.

[Abstract] The design of an active microwave band-pass filter is described which yields the desirable elliptic amplitude-frequency characteristic and minimizes insertion losses while compensating dissipation losses. Such a filter consists of a passive one with two 3-arm circulators and two resonance cavities containing an IMPATT diode each. The performance of such a filter was checked experimentally, after it had been built with the following components. The passive filter consisted of three sections with quarter-wavelength couplings, each section formed by an array of inductive posts inside a rectangular waveguide with  $5 \times 23 \text{ mm}^2$  cross-section. The circulators consisted each of open rectangular waveguide segments with  $5 \times 23 \text{ mm}^2$  cross-section and a 10Sch6 YAG ferrite disk (5 mm diameter, 5 mm thickness), with a matching dielectric cylinder (4.5 mm diameter, 5 mm height) in each arm. The resonators were each formed by a segment of a rectangular waveguide with  $5 \times 23 \text{ mm}^2$  cross-section and a short-circuit. The passive filter set the bandwidth at 100 MHz and the insertion loss at 1 dB, with matching in the pass band equivalent to an  $\text{SWR} \leq 1.2$  standing-wave



ratio. Independent control of the bias current in each IMPATT diode from a stabilized power supply eliminated variance of circuit parameters and ensured constancy of filter characteristics within 1%. Measurements were made over the 10.5-10. GHz frequency range. Figures 2; references 4: 3 Russian, 1 Western.  
[259-2415]

UDC 621.372.852:537.86

#### NATURAL OSCILLATIONS OF ELECTROMAGNETIC FIELD IN DIELECTRIC RESONATOR IN WAVEGUIDE JUNCTION

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 9 Nov 83) pp 417-421

KOROBKIN, V. A. and OSINTSEV, V. V.

[Abstract] The electrodynamic problems of natural oscillations and resonances are rigorously formulated for a dielectric filler-resonator in an H-plane tee connecting two rectangular cutoff waveguides. The problem is solved for  $H_{ps0}$ -modes, which carry only the  $E_z$ -component of the electric field ( $p$  and  $s$  denoting the numbers of space half-periods along  $X$  and  $Y$  axes respectively). Calculations are made by the method of partial regions, with the field in the dielectric region represented as superposition of the fields in intersecting waveguides and considering that the electric field is zero in metal walls everywhere. The algorithm of the solution process has been programmed in FORTRAN-4 for a YeS-1022 computer. The results reveal two kinds of natural oscillations of the electromagnetic field, those whose corresponding modes do and those whose corresponding modes do not propagate through the dielectric waveguide segments. A smooth transition from one type to the other can be affected by change of the junction geometry or by change of the dielectric material. Numerical results for  $H_{110}$ ,  $H_{210}$ ,  $H_{220}$  modes (widths of the two intersecting waveguides  $a/b = 1, 2, 1$  respectively) agree closely with experimental results pertaining to three dielectric materials: Teflon-4 ( $\epsilon = 2.2$ ), Textolite ( $\epsilon = 4.75$ ), leucosapphire ( $\epsilon = 9.2$ ). Use of a dielectric filler thus allows not only size reduction but also range extension. Figures 4; tables 1; references: 5 Russian.  
[307-2415]

## INPUT IMPEDANCE FUNCTIONS FOR SEGMENTS OF NONHOMOGENEOUS TRANSMISSION LINES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 30 Dec 82) pp 422-426

ZAKHAROV, A. V.

[Abstract] Using segments of nonhomogeneous transmission lines connected in series or parallel provides the necessary flexibility for optimizing the characteristics of microwave devices. A design and performance analysis of such distributed circuits requires knowing their input impedance. In the ideal lossless case their input impedance is described by an infinite-order reactance function of the complex variable in the frequency domain, with certain constraints. These constraints are established here for both one-dimensional (linear) and multidimensional (branching) nonhomogeneous distributed LC-networks. These constraints pertain essentially to the spacing of zeros and poles in the complex plane which, according to a theorem demonstrated here, requires that: 1)  $0 < \lim_{n \rightarrow \infty} \omega_{0n}/n = \lim_{n \rightarrow \infty} \omega_{pn}/n < \infty$

2) symmetry of the limits of convergent sequences within the infinite sequence  $0 < (\omega_{0n+1} - \omega_{pn})/(\omega_{0n+1} - \omega_{0n}) < 1$  with respect to  $1/2$ ;

3)  $\sum_{n=1}^{\infty} 1/L'(\omega_{pn})^2 = \infty$  ( $L'(\omega) = \omega \prod_{n=1}^{\infty} (1 - \omega^2/\omega_{pn}^2)$ ). These constraints

( $n$ - order of zero  $O$  or pole  $P$ ) apply to open-circuited segments and, with the third constraint appropriately modified, to short-circuited segments. They are demonstrated on the simplest possible branching network consisting of three nonhomogeneous line segments and then extended to one consisting of  $N$  such segments all whose parameters are whole functions of the complex variable. Figures 2; references: 8 Russian.  
[307-2415]

## SELF-MODULATION INSTABILITY OF GYROTRON EMISSION

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 23 May 83) pp 563-570

NUSINOVICH, G. S. and ZAPEVALOV, V. Ye.

[Abstract] A gyrotron with an axisymmetric interaction space and with an open resonator consisting of slightly irregular waveguide segments is an excellent short-microwave oscillator, its radial modes being easily selected by varying the radius of the thin tubular electron beam, but selection of its azimuthal modes being more difficult. One problem is simultaneous self-excitation of competing modes during cyclotron resonance, two or more modes depending on the resonator diameter, which tends to lower the stability of the useful mode. Instability of an individual mode during synchronous interaction, manifested by a simultaneous appearance of two side modes "-1" and "+1", is equivalent to self-modulation of that center mode "0". A method of analyzing this kind of instability is proposed which applies to a broad class of electronic masers with arbitrary nonlinearity and arbitrary frequency separation between competing modes. Analysis by this method is based on the corresponding self-consistent system of three equations, including one equation of electron ballistics and two equations of mode excitation, with the power of beam-field interaction represented by a triple integral. These equations are formulated here for a multimode gyrotron with an axisymmetric interaction space and a high-Q resonator, and a thin tubular monoenergetic electron beam with negligible velocity dispersion, assuming also a negligible space-charge field. From these equations are derived two equations describing steady-state emission in the center mode alone. The second of them describes the power balance. The first one and its complex-conjugate are reduced to a pair of nonhomogeneous first-order differential equations without the azimuthal coordinate, with zero boundary conditions, whereupon this pair is reduced to two pairs of coupled equations without the amplitudes of the side modes. A numerical analysis reveals that, while a wider frequency separation between modes widens the instability zone for the center mode, a slight asymmetry of the mode spectrum does not significantly narrow down the stability zone. The results also indicate that within the cyclotron resonance band there is an optimum frequency separation corresponding to maximum efficiency of emission in a stable center mode. As the resonator diameter is increased, the mode spectrum becomes more crowded so that the frequency separation between the center mode and the nearest pair of side modes may become smaller than the critical frequency separation corresponding to minimum electron beam current, and then the pair of side modes nearest to those critical frequencies becomes most detrimental. The authors thank M. A. Moiseyev for discussing the results. Figures 3; references: 11 Russian.  
[307-2415]

## STIMULATED EMISSION FROM HIGH-CURRENT ELECTRON BEAM IN ONDULATOR DURING CYCLOTRON RESONANCE WITH COMBINATION-FREQUENCY WAVE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 23 Jun 83) pp 571-576

GRIGORYEV, V. P., DIDENKO, A. N., MELNIKOV, G. V., ZHERLITSYN, A. G.,  
FOMENKO, G. P. and SHTEYN, Yu. G.

[Abstract] A high-current electron beam is considered as source of energy for three-wave interaction in a short-microwave undulator, such an electron beam requiring application of a strong longitudinal magnetic field and thus also becoming a source of stimulated emission during cyclotron resonance not only with the interacting signal and pump waves but also with the combination-frequency wave. This phenomenon was analyzed theoretically by the Grigoryev method, on the basis of the kinetic theory. It was also studied in an experiment with an undulator in the form of a helical bifilar current-carrying conductor around the interaction space inside a circular cylindrical waveguide. An electron beam with  $E_c \approx 0.75$  MeV and  $I_b = 5 - 10$  kA was produced by the electron gun of the Tonus-1 high-current accelerator. The undulator helix was 50 cm long with a 28 mm pitch and had an inside diameter of 20 mm. The corresponding dependence of the emission power on the magnetic field was characterized by a wide peak over the  $B_z = 5 - 11$  kG range, containing resonance  $\omega_2 - k_z v_0 = \Omega_{01}$  with the signal wave within  $B_z \approx 6 - 8$  kG and resonance  $k_0 v_0 = \Omega_{02}$  with the pump wave within

$B_z \approx 7.5 - 10.5$  kG, and also a narrow peak over the  $B_z \approx 14 - 16$  kG range corresponding to resonance  $\omega_2 - k_z v_0 + k_0 v_0 = \Omega_{03}$  with the combination-frequency wave. Maximum power of approximately 20 MW was attained at 8.5 kG, during cyclotron resonance with the pump wave, but an efficiency of 0.5-1% and thus much lower than the theoretical efficiency of 30-35%. This very low efficiency is attributable to the very small waveguide diameter. Figures 3; references 12: 8 Russian, 4 Western.  
[307-2415]

## SIMULATION AND ANALYSIS OF MULTIFREQUENCY OPERATING MODE OF M-TYPE AMPLIFIERS WITH DISTRIBUTED CATHODE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 11 Nov 83) pp 577-586

TERENTYEV, A. A., ILIN, Ye. M. and BAYBURIN, V. B.

[Abstract] A multifrequency cylindrical model is constructed for describing an M-type amplifier with a distributed cathode, including both azimuthal and



radial components of the Coulomb field. Analysis of multifrequency interaction and amplifier performance according to this model involves simultaneous solution of the equations of electron motion and mode excitation. Into account is taken dispersion of the retarding structure. Time variation of the phase difference between the input signals results in amplitude and phase fluctuations of the output signal, periodic ones in the case of an equidistant mode spectrum and quasi-periodic ones in the case of a non-equidistant mode spectrum. For simulation and evaluation, this problem is overcome by averaging over  $S$  periods of the high-frequency field and then letting  $S \rightarrow \infty$ . Numerical calculations have been made on this basis for amplification of a two-frequency signal by a backward-wave amplatron. The effect of combination-frequency components is found to be some attenuation of the main signals, with a slight increase of the anode current and with some asymmetry of the output spectrum in the case of equally large input signals. Further calculations also indicate the feasibility of three-frequency operation, however at an efficiency at least 5-10% lower than that of single-frequency operation. The authors thank V. I. Gayduk for helpful comments. Figures 8; references 14: 12 Russian, 2 Western.

[307-2415]

UDC 621.331:681.3

POSSIBILITIES FOR AUTOMATION OF TRACTION SUBSTATIONS THROUGH USE OF MICROPROCESSORS

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 85 (manuscript received 25 May 83) pp 27-31

ZHARKOV, Yu. I., candidate of technical sciences, dotsent, Rostov Institute of Railroad Transport Engineers

[Abstract] The paper describes a real-time operation microprocessor in formation-control complex required for development and improvement of the automation of control of traction substations. A block diagram is shown of this complex and a functional algorithm of the central and local control system is given. The paper was submitted by the Department of Electrical Power Supply for Electrical Railroads. Figures 2; references: 2 Russian. [264-6415]

UDC 62=83:62=523.001.4

DETERMINATION OF PARAMETERS OF ASYMMETRICAL OSCILLATIONS IN SUBORDINATE CONTROL SYSTEMS FOR ELECTRIC DRIVES SUBJECTED TO CONSTANT PERTURBATION

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA in Russian No 4, Apr 85 (manuscript received 23 Feb 84 after revision) pp 109-113

PORTNOY, N. Ya.

[Abstract] Determination of the amplitude and frequency of the output oscillations of a relay subordinate control system is investigated. Expressions are derived for the frequency and amplitude of self-sustained oscillations as a function of the value of the constant component. The formulas obtained can be used to determine the parameters of asymmetrical oscillations for various values of the coefficients of the structural diagram. Figures 5; references: 1 Russian. [289-6900]

UDC 621.375.13

HIGH-SPEED AMPLIFIERS WITH MULTILoop FEEDBACK

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 6 Jul 84) pp 43-46

OSIPOV, A. I. and PLESHKO, A. D.

[Abstract] While amplifiers with "leap frog" multiloop feedback feature high stability over the entire operating frequency range, in agreement with the theory of active filters, their design for fast response and thus best dynamic performance requires optimization of the amplitude-frequency characteristic or the transient characteristic. Such a design procedure is applied to multistage wideband amplifiers, with the number of poles of the transfer function equal to the number of stages, and to pulse amplifiers. In the first case the design is based on general expressions for the transfer function and the amplitude-frequency characteristic, the latter usually in the Chebyshev approximation of a maximally flat one. In the second case the optimum transient characteristic must be calculated for each specific value of the nonuniformity factor. Figure 4; tables 1; references 8: 6 Russian, 2 Western.  
[259-2415]

UDC 621.374.5

ENERGY-ECONOMICAL TIME INTERVAL GENERATORS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 27 Jun 84) pp 89-91

BAKALINSKIY, V. P., BICHUKOV, V. D., SEMENENKO, I. G. and KHLON, A. G.

[Abstract] The circuits of two bridge-type time-interval generators are described, one with switching of the common supply busbar and one with switching of the high-potential supply busbar, each built with series 561 and 564 microcircuit chips ensuring high energy economy. The first circuit includes a repeater with logic "1" output potential, a comparator with common busbar under logic "1" potential, with an inverting input and a noninverting

input, also a NOT gate with logic "0" output potential, and a time setting capacitor. The instability of an 8.12 ms time interval generated by this circuit was found not to exceed 0.2% during fluctuations of the supply voltage over the  $\pm 10 \pm 5$  V range and 1.5% during fluctuations of the ambient temperature over the 20-100°C range. The second circuit includes an OR gate and two repeaters with logic "0" output potentials, a comparator with potential busbar under logic "0" potential when disconnected, and a time setting capacitor. The instability of a 10.3 ms time interval generated by this circuit was found not to exceed 0.2% during fluctuations of the supply voltage over the  $\pm 10 \pm 5$  V range and 0.1% during fluctuations of the ambient temperature over the 20-100°C range. The time setting capacitor was not placed inside a temperature changer during measurements. In the driven mode both circuits draw hardly any energy at all, the logic gates constituting the only energy users then and their energy requirement being negligible. Figures 2; references: 2 Russian. [259-2415]

UDC 535.317(012)

#### IMPROVED INFORMATION FOR OPTICAL-SYSTEM DEVELOPMENT PROCESS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85 (manuscript received 23 Nov 83) pp 37-39

ALEKSANDROV, L. V., ANDREYEV, V. P. and ZYL, V. P.

[Abstract] A new 3-digit code and graphic symbols are proposed for designation of the relatively few different lens forms available for automated development and design of optical systems. The code covers 11 kinds of lenses, namely 5 converging ones thickest at the center (one biconvex, two plano-convex, two concavo-convex with positive menisci) and 5 diverging ones thinnest at the center (one biconcave, two plano-concave, two convexo-concave with negative menisci) as well as a plane-parallel plate. A matrix chart is also proposed for classification and location of USSR patents covering optical lens systems, with identification of both preceding and following lenses in such systems. Computer-aided patent search for analysis of a given optical system can be based on such a matrix chart as well as on standard graphs of engineering solutions for given sequences of given optical elements, or plainly on combinations of individual forms of optical lenses. Figures 3; references: 3 Russian. [271-2415]



## EXPERIMENTAL-DESIGN METHOD OF SYNTHESIZING RADIO ENGINEERING DEVICES

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 27 Jun 83) pp 544-549

MESHCHANOV, V. P. and CHUMAYEVSKAYA, G. G.

[Abstract] A method of synthesizing radio engineering devices is proposed which heavily involves experiments so as to ensure precise results on the basis of an initially simplified mathematical design model. The gist of this method is treating physical realization in the form of a prototype not as the final step but as an intermediate, the middle step, of the procedure. The latter consists of 11 steps: 1. formulation of the problem of synthesis; 2. selection of the electric circuit structure; 3. construction of the mathematical model; 4. numerical solution of the problem of analysis; 5. solution of the problem of approximation; 6. physical realization of the prototype; 7. experimental solution of the problem of analysis by measurement of the prototype characteristics; 8. construction of a new approximating function; 9. solution of the second problem of approximation; 10. physical realization of revised version; 11. measurement of its characteristics. There is feedback from step 5 to steps 1 and 2, from step 6 to steps 1 and 2, and from step 11 to step 8. The procedure has been applied to synthesis of asymmetric 3-stage and symmetric 5-stage microwave directional couplers. It is very effective for large-scale production of devices with one set of tools, with the possibility of correcting systematic dimensional errors which follow deviations from the specified technology. Figures 5; tables 2; references: 4 Russian.  
[307-2415]

UDC [621.335:625.2.012.858:538.65]:621.313.13-12

INFORMATION-MEASUREMENT SYSTEM FOR INTEGRATED INVESTIGATION OF ELECTROMAGNETIC SYSTEMS

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA  
in Russian No 4, Apr 85 (manuscript received 27 May 83) pp 81-84

NIKITENKO, A. G., GRINCHENKOV, V. P., LOBOV, B. N. and TYNDIK, V. V.

[Abstract] An information-measurement system is described for performing integrated investigations of static and dynamic electromagnet operating modes. The system is capable of contactless determination of the size of air gaps ranging from 2 to 25 mm between the stationary and moving elements of the magnetic conductor, measuring average current of up to 500 A and voltage up to 1000 V, determining the magnetic flux in given cross-sections of the conductor, measuring the winding current at 10 points, and determining the interaction forces between the electromagnetic and the moving element using a four-point scheme. The functional diagram of the system is presented and explained. Implementation of the system speeds the completion of experiments, improves their quality, and reduces the number of engineering and technical personnel required for experimental investigation of large electromagnets and special technological devices. Figures 1.  
[289-6900]

UDC 621.313.13.001.24:681.3:519.2

COMPUTER ANALYSIS OF CORRECT ENERGY CHARACTERISTIC OF MECHANISM INCORPORATING ELECTRIC DRIVE

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA  
in Russian No 4, Apr 85 (manuscript received 11 Jul 84 after revision)  
pp 98-100

AVILOV-KARNAUKHOV, B. N., ZYUBROSKIY, L. G. and POTAPENKO, V. Ya.

[Abstract] A FORTRAN program for YeS series computers is described that implements a method derived elsewhere by the authors for determining the correct energy characteristic of a mechanism incorporating electric drive.

The characteristic is determined as the relationship between the power consumed by the mechanism and its output, based on solving an ill-conditioned system of algebraic equations using Tikhonov regularization. The energy characteristics of the MShR-3600x4000 ball mill are calculated for two operating modes. The relationships obtained can be used to analyze the power consumption of a machine as its operating mode changes (the output and turning speed of a ball mill, inter alia). Figures 1; references: 7 Russian.  
[289-6900]

UDC 537.2.213

#### CHARGE DENSITY IN THIN DISK INSIDE THIN CHARGED CONDUIT

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 6, Jun 85 (manuscript received 23 Mar 84) pp 31-36

GRACH, I. M., candidate of technical sciences, docent, ASHIRKULOV, M. A., candidate of technical sciences, and FAYDA, M. N., engineer, Frunze Polytechnic Institute

[Abstract] Coplanar electrode pairs consisting of a charged thin flat disk conductor inside a charged thin conduit, typically an annulus, are used in some high-voltage devices and in diaphragm-type electrolyzers as well as in various measuring instruments. In order to determine the electric field in such a structure, where disk and conduit carry equal charges of opposite polarities, it is necessary to calculate the charge density in the disk. This calculation can be simplified by replacement of the exact two-dimensional Laplace equation in cylindrical coordinates for a plane-meridional field

$$\frac{1}{r} \frac{\partial V}{\partial r} + \frac{\partial^2 V}{\partial r^2} + \frac{\partial^2 V}{\partial z^2} = 0 \text{ with the equation for an analogous plane-}$$

parallel field

$$\frac{\partial^2 V}{\partial r^2} + \frac{\partial^2 V}{\partial z^2} = 0 \text{ and thus letting } \frac{1}{r} \frac{\partial V}{\partial r} \rightarrow 0 \text{ within a small sub-}$$

region adjacent to the plane disk surface. An expression for the charge density  $\sigma = k\sigma_p$  is derived on this basis, with the aid of the Keldysh-Sedov relation for the complex field intensity and with subsequent evaluation of  $k$  in accordance with Gauss's theorem. The accuracy of this method has been established in a computer-aided evaluation of the double integral for the potential at a disk surface as function of the charge density distribution. Subdivision of the range of integration over the disk radius first into 100 and then into 250 intervals yielded in the first case a difference between maximum and minimum values of the potential not exceeding 5% of the minimum value. The same method is applicable to problems where the electrode potentials are given, but then it is necessary to let  $\sigma = k_1\sigma_p + k_2$  with  $k_1 = \text{const}$  and  $k_2 = \text{const}$ . Article was presented by Department of Theoretical and General Electrical Engineering. Tables 1; references: 3 Russian.  
[310-2415]

## MAGNETICS

UDC 621.3.042.143.013:51

### NUMERICAL METHOD OF ANALYSIS OF PARAMETERS OF ELECTROMAGNETIC FIELD IN MAGNETIC CONDUCTORS

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 85 (manuscript received 25 Apr 84) pp 45-49

GERASIMOVICH, A. N. and BULAT, V. A., candidates of technical sciences, Belorussian Order of the Red Banner of Labor Polytechnical Institute

[Abstract] A numerical method of analysis is developed which makes it possible to calculate the parameters of an electromagnetic field penetrating into a conducting media with nonlinear characteristics in a regime with a specified law of change of the magnetic flux and can be used in the design of various electrical engineering devices which contain laminated magnetic conductors. The method considered was demonstrated by calculating values for the electric field  $E$  and magnetic induction  $B$  in a sheet of 3413(E330) electrical engineering steel and the results were found to be in accord with the physics of electromagnetic processes. The paper was submitted by the Department of Electrical Stations. Figures 3; references: 5 Russian. [264-6415]

UDC 621.039.514.25

### ANALYSIS OF TRANSIENTS IN AXISYMMETRICAL SYSTEMS WITH ALLOWANCE FOR INFLUENCE OF EDDY CURRENTS IN MASSIVE PARTS OF MAGNETIC CONDUCTOR.

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA in Russian No 4, Apr 85 (manuscript received 22 Oct 84 after revision) pp 11-14

KERSHOV, Yu. K.

[Abstract] A simplification is proposed for Kolesnikov's algorithm for calculating transients in axisymmetrical systems. The simplification is achieved by splitting the working magnetic flux  $\Phi$  in the linear axisymmetrical system into the fluxes  $\Phi_0$  created by the magnetizing force of the



winding, and  $\Phi_v$  created by the eddy currents of the massive parts. The magnetic field of the current windings is plane-meridional, and the eddy current field is assumed to be unidirectional in the massive parts of the magnetic conductor. A shell-type magnet system is analyzed in order to validate the simplifying assumptions. A program implementing the algorithm that runs on a YeS-1022 computer is described. When 10 terms are used, the error of the discarded terms is no greater than 3%. Figures 2; references: 7 Russian.  
[289-6900]

UDC 681.325.5:518.5

UNIVERSAL FUNCTION COMPUTING ALGORITHM FOR MICROPROCESSORS

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA  
in Russian No 4, Apr 85 (manuscript received 9 Feb 84) pp 73-76

ANISHIN, N. S.

[Abstract] A universal algorithm for computing functions (exponential, logarithmic, and trigonometric) that can be implemented on 8- or 16-bit microprocessors is proposed and validated. The iterative algorithm can be adjusted to compute a particular function by assigning the initial values of the four quantities that are involved in the iterations and that ensure that the iterative process converges at the point at which one of the coordinates is equal to the value of the sought quantity. A flow chart of the algorithm is presented, along with a detailed presentation of the algorithm at the machine instruction level. The proposed algorithm can be employed in information-measurement or control systems where the conversion accuracy requirements are relatively lax (with acceptable error of 0.01-0.1%). Figures 2; references: 3 Russian.  
[289-6900]

UDC 621.316.925

IMPROVEMENT OF PROTECTION OF 0.38 kV OVERHEAD LINES FROM BREAKING OF CONDUCTORS

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 4, Apr 85 (manuscript received 17 Sep 84) pp 35-38

KOBAZEV, V. P., engineer, and SELIVAKHIN, A. I., candidate of technical sciences, Moscow Order of the Red Banner of Labor Institute of Engineers of Agricultural Production imeni V. P. Goryachkin, ZHELIKHOVSKIY, Kh. M., Donetsk Order of the Red Banner of Labor Polytechnical Institute

[Abstract] The paper is concerned with an improvement of a device used for protection of 0.38 kV overhead lines from breaking of conductors. The substational deficiencies of known protection devices are described. A block diagram of the functional circuit of a protection device is shown. A protection device containing a compensation circuit was tested in an operating 0.38 kV network at the Donbassenergo Donetsk Unit. The tests confirmed the efficiency and performance of the circuit in all cases of conductor breaking. The paper was submitted by the Department of Electrical Power Supply of Agricultural Production. Figures 3; references: 5 Russian.  
[264-6415]

UDC 621.311.6.027.3.001.4

CONTROL AND REGULATION WITH PROTECTION OF HIGH-VOLTAGE POWER SUPPLY

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 26 Jul 84) pp 22-25

PRIDATKOV, A. G., candidate of technical sciences, and VOLKOV, L. R., engineer, Institute of Power Engineering imeni G. M. Krzhizhanovskiy

[Abstract] A controllable high-voltage power supply with voltage regulation is most expediently built in the form of a converter operating from the 3-phase a.c. network through a step-up transformer, with a controlled-rectifier bridge on either the primary or the secondary side.

The fixed-rectifier bridge is connected across the transformer secondary winding and shunted by a filter-capacitor. As a regulator of the a.c. voltage on the low-voltage (primary) side one can use parallel-opposing thyristor pairs connected into each phase through a choke coil in series or a controlled-rectifier thyristor bridge loaded by a choke coil. Reliable regulation with high response speed and insensitivity to line voltage and line frequency fluctuations or waveform distortions can be combined with protection of such a high-voltage power supply by means of pulse-phase control according to the single-channel asynchronous method, which minimizes asymmetry and ensures excellent dynamic characteristics. A major problem here is setting the limits of the control range, namely its minimum and maximum phase angles. This problem has been solved in a control-regulation-protection system consisting of a limits setter, a pulse selector, and a pulse distributor in series forming a single channel. The limits setter is a commutator, three groups of six sequentially operating switches and two potentiometers with null-point drivers across the outputs. It is connected across the a.c. line through a step-down transformer with a filter-converter on the secondary side which converts the 3-phase voltages into 6-phase reference signals by means of an integrator followed by an inverter. The pulse selector with AND and OR logic processes pulse signal sequences and picks the one whose phase position corresponds to the required control angle, feeding it to the pulse distributor as well as to a regulator. The pulse distributor, which consists of a counter, a decoder, and logic, splits the single-channel sequence into two six channels spaced  $60^\circ$  apart in phase, feeding the  $180^\circ$  long sequence to a pulse shaper for the thyristor bridge and the  $60^\circ$  long sequence back to the limits setter. The regulator has two independent channels, one for voltage stabilization and one for current stabilization or cutoff. Their combined operation yields a  $\Gamma$ -form output characteristic of the power supply, both channels based on asynchronous setting of the control angle by means of an integrator with a throw-off switch in parallel and a comparator in series. The current channel is also connected to an overcurrent protector which feeds signals to the logic of the pulse distributor. A secondary power supply for this control-regulation-protection system has been developed without a transformer, for size and weight reduction, which generates stabilized  $\pm 15$  V d.c. for the microcircuits as well as 36 V (peak) - 50 Hz and +48 V d.c. for the pulse shaper, maintaining these voltages within less than 1% during  $\pm 15\%$  wide fluctuations of the line voltage and during swings of the load from open to short circuit. The transient period after load throw-on or throw-off is of the order of 100 ms and depends on the time constant of the load circuit. Figures 2; references: 2 Russian.

[265-2415]

## ACTIVE MAGNETIC SUSPENSION IN MAIN MAGNETIC FIELD OF ELECTRIC MOTOR

Moscow ELEKTROTEKHNIKA in Russian No 3, Mar 85 (manuscript received 24 Apr 84)  
pp 38-41

URUSOV, I. D., doctor of technical sciences, professor, GALKIN, V. I.,  
candidate of technical sciences, and LIKHOSHVAY, I. P., engineer

[Abstract] An active magnetic suspension for the rotor of an electric motor is considered, especially in small or miniature high-speed devices such as gyros, microturbomachines, and machine-tool spindle drives where it would eliminate the need for extra bearings and contribute to size and weight reduction. A disk-type rotor made of a ferromagnetic material is located horizontally inside the bore of a vertical stator so that weight and external loads compensate the magnetic pull upward. This pull is generated by the magnetic field in the air gap and can be automatically controlled by an electronic feedback circuit which regulates the stator input voltage depending on the rotor position along the stator bore, with a displacement transducer on the rotor indicating the position. The performance of such a suspension with automatic control in a 3-phase induction motor is analyzed on the basis of the system of differential equations describing the behavior of the electromechanical system during axial oscillations of the rotor, assuming a constant rotor speed during the transient periods. This assumption is valid for high-speed electric motors, characterized by a mechanical time constant in the direction of rotor speed during the transient periods. This assumption is valid for high-speed electric motors, characterized by a mechanical time constant in the direction of rotation much longer than the time constant of linear rotor oscillations, and allows omitting the torque equation. A solution of the remaining system of equations by the method of Laplace transformation, after linearization and reduction to two orthogonal axes of coordinates, yields the transfer function of the suspension system for calculation of its dynamic and static characteristics - as basis for designing the structure of the automatic control system. Computer-aided theoretical calculations yield a transient with the first overshoot of slightly larger magnitude and slightly shorter duration than indicated by oscillograms of an experimentally built motor with rotor suspension. Figures 5; references: 4 Russian.  
[265-2415]



## MAIN ASPECTS OF ENERGY CONSERVATION PROGRAM FOR NEAR FUTURE

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 6, Jun 85 (manuscript received 22 Feb 85) pp 3-7

DOBROKHOTOV, V. I., doctor of technical sciences, and VOLFBURG, D. B., candidate of economic sciences, USSR State Committee on Science and Engineering

[Abstract] The energy policy for the next 15-20 years aims at growth of nuclear power along with more extensive production of fossil fuels and development of renewable energy sources. There is also energy conservation included in the program, its main aspects being more extensive use of already available technologies and equipment, their modernization or replacement, better utilization of secondary energy sources, improvement of the energy production-distribution-consumption structure, comprehensive automation of processes and equipment, improvement of monitoring and accounting procedures, and accelerated introduction of new energy conversion methods. Achievement of these goals requires industry-wide planning as well as participation of all enterprises, with a thorough analysis of fuel demand and energy balance in the latter, for optimization of the overall fuel and energy economy depending on the production mode. In addition to these short-range measures, which also include upgrading the skills of personnel, there are intermediate-range and long-range measures. The former are construction of atomic electric power plants relieving the demand for scarce fossil fuels, construction of high-efficiency thermal electric power units running on solid fuel, construction of pumped-storage hydroelectric power plants, gas turbine sets, steam turbine sets, and gas-steam turbine sets with high degree of maneuverability, development and management of electric energy distribution over superhigh-voltage a.c. and d.c. transmission lines, construction of large hydroelectric power plants in Siberia and Central Asia as well as smaller hydroelectric power plants with full automation, restructurization of currently operating systems for higher efficiency, more centralized production of heat, redesign of equipment with more economic use of materials and for longer service life, further utilization of secondary energy sources such as industrial and urban waste. Among the long-range measures are development of renewable energy sources such as solar, wind, geothermal, biomass, and tidal power, use of nuclear power in metallurgy and chemical industries, introduction of entirely new types of low energy-and-material consuming production systems, development of high-capacity heat and electric energy storing devices, research in hydrogen technology, thermonuclear fusion, cryogenics, and new types of nuclear reactors, and development of synthetic liquid fuel from coal and shale.

[310-2415]

## CURRENT DENSITY DISTRIBUTION OVER SURFACE OF PIN INSULATOR DURING DISCHARGE BUILDUP

Minsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: ENERGETIKA in Russian No 6, Jun 85 (manuscript received 15 May 84) pp 37-41

SKORNYAKOV, V. A., candidate of technical sciences, and ALVARES, E. Kh., engineer, "Order of Lenin" Leningrad Polytechnic Institute imeni M. I. Kalinin

[Abstract] For an analysis of flashover at a moist or dirty pin insulator, a mathematical model is constructed describing the spread of leakage current from the base point of an arc on the cylindrical pin surface between two petticoats toward the latter. The model is based on the complex electric potential in the current spreading region and the applicable form of Ohm's law. The current is assumed to spread symmetrically in both directions. A transformation in the complex plane, for extraction of the imaginary component of the potential, yields the leakage current. The width of the zone within which 95% of the leakage current flows is then calculated as function of the distance from a given point along its path to the arc base point. This distance, found upon integration of the current density, is inversely proportional to the distance between petticoats. A narrowing of the current path results in a higher resistance of that path per unit length and a correspondingly lower current threshold level at which flashover will occur with an attendant sharp decrease of the discharge voltage. Article was presented by Department of Electrical Apparatus. Figures 3; references 5: 4 Russian, 1 Western.  
[310-2415]

## CHOICE OF CABLE CROSS-SECTION FOR NONSINUSOIDAL CURRENTS

Minsk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: ENERGETIKA in Russian No 6, Jun 85 (manuscript received 23 Aug 83) pp 41-45

TROFIMOV, G. G., candidate of technical sciences, docent, and SOYSOYEV, V. V., engineer, Alma-Ata Institute of Power Engineering

[Abstract] Selection of the cable size on the basis of the heating criterion must take into account all power losses so as to ensure that the operating temperature does not exceed the nominal allowable level for a given cable insulation system. The a.c. power losses in the conductor and in the dielectric, proportional to current squared and voltage squared respectively, as well as in the protective cable components (shield, sheath, armor) are calculated according to standard formulas, whereupon the equivalent resistances together with the resistances representing the

skin effect and the proximity effect are added to the d.c. resistance of the conductor alone. This general procedure is applied to cables carrying non-sinusoidal currents. A correction factor accounting for the contribution of current harmonics is used which depends on the shape and the area of the conductor cross-section as well as on the conductor spacing, considering also that the dielectric loss becomes negligible at higher frequencies. Sectoral high-voltage cables are of particular interest in this design analysis, different numerical values and ranges for the correction factor applying to 6 kV and 10 kV cables respectively. The design is ultimately based on an operating current not higher than the nominal allowable current reduced by three factors smaller than unity, one of them accounting for nonsinusoidality. Typical values of this factor for a 240 mm<sup>2</sup> copper cross-section are 0.933 with sheath loss disregarded and 0.79 with sheath loss and up to 13 harmonic included or 0.74 with sheath loss and up to 25 harmonics included. This variance indicates a need for refinement of this correction factor. Article was presented by Department of Electric Power Supply for Industrial Enterprises. References: 4 Russian. [310-2415]

UDC 624.97.551.594.001.4

#### MATHEMATICAL MODELING OF MAIN LIGHTNING STAGE

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85 (manuscript received 4 Dec 84) pp 10-16

GORIN, B. N., candidate of technical sciences, Institute of Power Engineering imeni G. M. Krzhizhanovskiy

[Abstract] A mathematical model is constructed describing the main stage of lightning buildup. The corresponding system of two differential equations for the potential and the current, in the one-dimensional approximation, is based on the analog of a spark in a long discharge gap and on a power function of time (power exponent  $n = 1.5-4$ ) simulating the voltage transient. All parameters of the lightning channel are evaluated on the basis of applicable circuit relations and available data. The conductance is a function of the electric charge present as well as on the current pulse characteristics (rise time, amplitude, half-fall time), while the inductance is approximately constant and equal to that of an equivalent vertical conductor. The dynamic capacitance is more difficult to determine, requiring an analysis of the streamer field and the neutralization process. Reasonable assumptions are made regarding the electric field in a cylindrical vertical channel and, with all necessary parameters established, the system of equations is reduced to a form suitable for computer-aided numerical solution by the method of characteristics. Figures 5; tables 1; references 14: 8 Russian, 6 Western. [260-2415]

## NEW TRENDS IN DEVELOPMENT OF METHODS FOR ESTIMATING LIFE OF CABLES AND CONDUCTORS

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85  
(manuscript received 27 Dec 84) pp 20-22

PESHKOV, I. B., doctor of technical sciences

[Abstract] Several methods of estimating the life of electric cables and conductors have been recently developed, each of them based on some aspect of the aging process and aimed at establishing how some key characteristic of the insulation material changes as a function of time. These methods apply respectively to high-voltage oil-filled cables, low-voltage cables with thermoplastic polymer (polyvinyl chloride or polyethylene) insulation, and conductors with enamel coating, the last group constituting the ground-level product of the cable industry. The two characteristics best indicating the state of the insulation are the dielectric loss tangent and the loss of mass. The increase of either of them in time characterizes the aging process by a mechanism which depends on the type of insulation and on the service conditions. Thermal decomposition involving breakup of intermolecular and interatomic bonds is the principal aging mechanism in the case of oil-filled cables usually buried in a medium with a slow rate of heat dissipation, ionization having been found to have a negligible effect on the cable life even at high electric field intensities. Plastic flow is the principal aging mechanism in the case of solid polymers, chemical processes such as oxidation being predominant at higher temperatures up to and above the melting range and physical processes such as diffusional desorption being predominant at lower temperatures. A particularly novel approach is being taken with regard to enamel-coated conductors. Here conventional methods of accelerated testing in surface-active media are supplemented with new techniques of thermogravimetric analysis, for determination of the activation energy and the temperature index as indicators of insulation life. References: 6 Russian.

[260-2415]

UDC 621.313.013.001.24

## DETERMINATION OF ELECTROMAGNETIC FORCES IN MAGNETIC FIELD CALCULATIONS

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85  
(manuscript received 19 Mar 84) pp 58-60

NAZARYAN, A. G. [deceased], MAILYAN, A. L. and ADZHEMYAN, E. Kh.,  
Yerevan Polytechnic Institute

[Abstract] A procedure is outlined for determining the electromagnetic force in the equation of motion for an electrical machine. Instead of approximating the inductance, with an inevitable error compounded by



subsequent differentiation, the force is determined directly from the magnetic field distribution corresponding to a specific relative position of the electromechanical system components. The field pattern is most intricate, with the magnetic induction changing most abruptly, in the regions of strong fringing at corners of teeth or salient poles in the air gap. Calculations for plotting the magnetic field by the method of finite elements or finite differences according to the procedure devised by A. V. Ivanov-Smolenskiy yields most accurate results when the selected surfaces pass through points where components of magnetic induction have discontinuities or overshoots. The procedure is demonstrated on a machine with rectangular slots on both sides of the air gap and with the magnetic cores made of EIA steel. Two operating modes are considered, low saturation level with a uniform magnetic permeability of all iron  $\mu_r = 4200$  (slot currents 9 kA and 18 kA) and high saturation in the teeth with a magnetic permeability of the latter  $\mu_r = 2-6$  (slot currents 18 kA and 36 kA). The magnetization curves for all components of the ferromagnetic structure are approximated by being subdivided into seven segments representing a full third-degree polynomial each, except the linear last one, with different sets of coefficients for each. In calculating electromagnetic forces on the conductors in slots by this method, it has been found to be most expedient to treat them as tension forces. Figures 1; tables 1; references 6: 5 Russian, 1 Western (in Russian translation).  
[260-2415]

UDC 621.316.722.001.8

#### PULSE-TYPE VOLTAGE STABILIZER WITH INTEGRAL PULSE-WIDTH MODULATION

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85  
(manuscript received 21 Sep 84) pp 60-61

FEDOROVA, I. A., doctor of technical sciences, KUZNETSOV, A. P., candidate of technical sciences, and SHILIN, L. Yu., engineer, Minsk Institute of Radio engineering

[Abstract] Pulse-type voltage stabilizers combine high precision and efficiency with a size advantage and fitness for circuit integration. Such a voltage stabilizer with integral pulse-width modulation consists of a power amplifier followed by a low-pass filter for the line voltage, a reference oscillator and a variable-ratio frequency divider, and a pulse-phase detector which performs the integral control by comparing the two incoming signals from the reference oscillator and the frequency divider respectively, and feeds the mismatch signal to the power amplifier. The operation of such a voltage stabilizer is best analyzed on the basis of a system of two equations describing respectively the state vector and the output signal of its continuous linear amplifier-filter part, assuming that the latter has a constant structure, as functions of time. From these equations and the law of unipolar integral pulse-width modulation are obtained the performance characteristics of the voltage stabilizer in the



locking mode. The error-load characteristic, namely dependence of the output voltage deviation on the load resistance, and the stability limits as well as the locking band of a voltage stabilizer whose continuous linear part has the simplest transfer function  $W(p) = K_1/(T_1 p + 1)$  indicate that there is an optimum load resistance corresponding to the minimum stabilizer error, within 0.05% with typical filter components. An increase of the load resistance will gradually increase the error until the locking and stabilization limit is exceeded, because the pulse duration has exceeded the discretization period. The stabilizer error is in this range consistently smaller with an RC filter than with an RL filter. A decrease of the load resistance below that optimum will actuate the overload protection, as soon as the current rises to its safe limit, and thus cut out the voltage stabilizer altogether. Figures 2; references: 5 Russian. [260-2415]

UDC 621.314.6.001.24

#### COMPENSATED 12-PHASE CONVERTER WITH REACTOR-TRANSFORMER

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85  
(manuscript received 26 Oct 83) pp 31-37

ZBOROVSKIY, I. A., candidate of technical sciences, Sverdlovsk

[Abstract] A 12-phase converter with a step-down reactor-transformer is considered which has also a compensating coil wound on the same iron core and a capacitor connected across it. The performance of this device is analyzed on the basis of the corresponding system of algebraic and differential equations according to Kirchhoff's circuit laws, for steady-state and transient conditions respectively. In the general form these equations take into account the equalizing current which appears when the rectifier bridges are connected in parallel directly or through an equalizing reactor. They simplify appreciably when the quadrature reactance is infinitely large, which corresponds to the ideal case of a zero equalizing current in a parallel connection of rectifier bridges or to a series connection of the latter. The equations are solved for each characteristic time-angle interval of the switching cycle. On the basis of the solution is then calculated the converter load characteristic at various key values of the intrinsic firing angle and is also determined the dependence of the intrinsic firing angle on the switching angle in the principal mode of operation. The other critical performance characteristics are the peak inverse voltage across rectifier diodes, the 2-phase short-circuit current, and the distribution of the load current between the rectifier bridges in the absence of compensation. With these characteristics established, the reactor-transformer core can be optimally designed. The results of this analysis indicate the feasibility of obtaining a stiff load characteristic in operation with the intrinsic firing angle and of attaining an internal power factor near unity by using a high-frequency capacitor with low losses and with a reactance approximately 62 times higher than the

inductive reactance at the power line frequency. It also appears feasible to omit an equalizing reactor, by designing the transformer so as to ensure a sufficiently weak coupling between the rectifier windings. Figures 7; tables 1; references: 8 Russian. [260-2415]

UDC 621.314.632.001.24

CIRCUITS AND CHARACTERISTICS OF COMPENSATED POLYPHASE CONVERTER SYSTEMS WITH CAPACITOR OPERATING AT HIGH FREQUENCY

Moscow ELEKTRICHESTVO in Russian No 4, Apr 85  
(manuscript received 19 Oct 84) pp 38-42

KHOKHLOV, Yu. I., candidate of technical sciences, and  
KRASNOGORTSEV, I. L., engineer, Chelyabinsk Polytechnic Institute

[Abstract] For the purpose of a general and comparative performance analysis, polyphase rectifier-converter systems and specifically 12-phase ones consisting of two 6-phase rectifier banks are classified into those without and those with an additional reactor in the capacitive compensating circuit. This reactor can be connected closer to the load on the transformer secondary side or closer to the power network on the transformer primary side. The performance analysis of all converters in the principal mode of operation, without refiring, also with plain rather than controlled rectifiers is based on the generally applicable equation which describes the switching process in the forced commutation mode. The converter load characteristics are established next, namely the dependence of output voltage and power angle on the load current and the compensation factor. Other important characteristics are the current ripple factor and the capacitor current, both also depending on the load current. All these characteristics have been evaluated numerically on a YeS-1022 computer for typical ranges of the relevant circuit parameters (compensation factor), considering that the compensating capacitor operates at ripple frequency and that the two converter transformers can be  $Y/Y-\Delta/Y$  or  $Y/\Delta-\Delta//\Delta$  or  $Y/Y-Y/\Delta$  or  $\Delta/Y-\Delta/\Delta$  connected. Figures 5; references: 14 Russian. [260-2415]

UDC 621.384.3:681.7.068

NONLINEARITY OF FIBERTRONS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 25 Aug 84) pp 78-79

VOLCHKOV, V. P., GERBIN, I. A. and DMITRIYEV, V. P.

[Abstract] Deviation from linearity of fibertrons in analog-data optical communication systems is evaluated in terms of the ripple factor. An analytical expression for the latter is derived from the current transfer ratio and thus indirectly from the power-current characteristic, which depends on the parameters of transmitted light and on the physical properties of fibertron components. Most significant among these properties is the internal quantum efficiency of the radiator, determined by injection and recombination parameters as well as by geometrical design parameters. The analytical expression for the ripple factor as function of the input current with only a constant component and a fundamental alternating component, but with the output current also having a second harmonic and a third harmonic, yields somewhat higher values than the curve based on experimental data with the difference increasing as the input current does. The agreement can be improved by including higher-degree terms in the polynomial approximation of the current transfer function. Figures 1; references 5: 2 Russian, 3 Western (all in Russian translation).  
[259-2415]

UDC 535.345.6

PROPERTIES OF OPTICAL FILTERS ON CdSe-HgSe BASE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 19 Mar 84) pp 10-11

GAVALESHKO, N. P., PARANCHICH, S. Yu., PARANCHICH, L. D. and  
ANTOSHCHUK, V. G.

[Abstract] The two compounds CdSe and HgSe form pseudobinary alloys  $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$  whose energy gap  $e_g$  and refractive index  $n$  depend on the

composition and on the temperature according to the empirical relations

$$e_g = -0.22 + 2.06x + 0.0002(1 - 2.22x)\alpha \text{ eV} \quad \text{at } T < 100 \text{ K}$$

$$e_g = -0.2 + 2.015x + 0.0006(1 - 2.72x(T - 100))\alpha \text{ eV} \quad \text{at } T \geq 100 \text{ K}$$

$$n = 4.729(1 - 1.237x + 0.883x^2) - 0.00567\alpha(1 - 3.355x + 2.724x^2)T + 0.007717(1 - 3.443x + 2.781x^2)T^2$$

( $\alpha$  - linear thermal expansion coefficient  $6.26 \cdot 10^{-6} \text{ K}^{-1}$  for CdSe and  $5.57 \cdot 10^{-6} \text{ K}^{-1}$  for HgSe). The filter properties of these materials were measured in an experimental study, to supplement scarce available data and to determine the suitability of such filters for matching infrared devices with the window in the atmosphere. Their transmission spectra, wavelength dependence of the transmission coefficient over the 2-8  $\mu\text{m}$  range, were measured at 300 K (0.5 mm thick  $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$  filters with  $x = 0.3, 0.4, 0.45$  and 1 mm thick  $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$  filters with  $x = 0.8$ ) and at 80 K (1 mm thick  $\text{Cd}_x\text{Hg}_{1-x}\text{Se}$  filters with  $x = 0.8$ ). They were also measured before and after heat treatment at  $200^\circ\text{C}$  for 50 h in vacuum or in mercury vapor as well as before and after clearing with SiO. The data yield the basic filter characteristics, namely the maximum transmission coefficient  $T_{\text{max}}$  and the corresponding wavelength in a peaking spectrum or wavelength range in a flat spectrum, both long-wave and short-wave edges corresponding to  $0.5T_{\text{max}}$ , and the slope of the short-wave edge  $s = \lambda_{0.1T_{\text{max}}} / \lambda_{0.9T_{\text{max}}}$ . The

data are also useful for stoichiometric control of the transmission band as well as the transmission level. The transmission coefficient increases with an increase of the cadmium content  $x$ , owing to an increase of the energy gap which in this system varies from 0 to 1.8 eV. Annealing in vacuum increases the transmission coefficient at the long-wave end and decreases the slope of the short-wave edge, annealing in mercury vapor having a similar effect on the short-wave edge. Clearing with SiO can increase the maximum transmission coefficient up to 0.97 and the slopes of both edges up to 0.9 approximately. Figures 4; references 9: 5 Russian, 1 Polish, 3 Western (2 in Russian translation). [271-2415]

UDC 535.853.4

#### EFFECT OF PARASITIC REFLECTIONS ON INSTRUMENT CHARACTERISTIC FUNCTION OF SPECTROMETERS WITH SELECTIVE INTERFERENCE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85 (manuscript received 26 Mar 84) pp 12-14

GERSHUN, M. A., YEGOROVA, L. V. and KOTYLEV, V. N.

[Abstract] The effect of multiray reflections by an idle surface on the performance of spectrometers with selective interference is analyzed for a



typical such spectrometer with a tapered light-splitter plate and two diffraction gratings. The instrument characteristic function of such spectrometers is the sum  $A = \sum A_i$  of the complex amplitudes of waves which have passed through the optical system along different paths, as function of the referred wavelength  $\sigma = (\lambda - \lambda_0)R/\lambda$  ( $\lambda_0$  - wavelength to which the spectrometer has been tuned,  $R$  - reflection coefficient at the operative facet of the light-splitter plate). The intensity of light at the spectrometer exit is calculated on the basis of the instrument geometry and according to applicable relations of geometrical optics. The taper of the light-splitter plate is taken into account by correcting the referred wavelength to

$$\sigma' = 2\theta\sqrt{n^2 - \sin^2\gamma}L/\lambda\cos\gamma \quad (L - \text{width of aperture stop, } n - \text{refractive index of light-splitter material, } \gamma - \text{incidence angle, } \theta - \text{taper angle in horizontal plane, } \beta - \text{taper angle in vertical plane})$$

so that the instrument characteristic function becomes

$$A(\sigma) = \frac{\sin 2\pi\sigma}{2\pi\sigma} + M \frac{\sin 2\pi(\sigma + \sigma')}{2\pi(\sigma + \sigma')} + N \frac{\sin 2\pi\sigma'}{2\pi\sigma'} \cos 2\pi \frac{s_0}{L} \sigma$$

$$(M = \frac{Tr(1 - Rt)}{Rt(1 - rT)}, N = \frac{r(1 + Tt - Rt)}{t(1 - rT)}, R, T - \text{reflection coefficient and transmission coefficient at operative facet, } r, t - \text{reflection coefficient and transmission coefficient at idle facet, } s_0 - \text{distance between two adjacent parallel rays before interference. Numerical calculations are made for SP-101 and SP-140B spectrometers. The derivatives of two cadmium lines (643 nm, 847 nm) recorded by a spectrometer with tapered light-splitter are shown for illustration. Two argon lines (405 nm, 453 nm) recorded by a spectrometer with plane-parallel light-splitter are shown for comparison. Figures 3; references 6: 5 Russian, 1 Western. [271-2415]})$$

coefficient and transmission coefficient at operative facet,  $r, t$  - reflection coefficient and transmission coefficient at idle facet,  $s_0$  - distance between two adjacent parallel rays before interference. Numerical calculations are made for SP-101 and SP-140B spectrometers. The derivatives of two cadmium lines (643 nm, 847 nm) recorded by a spectrometer with tapered light-splitter are shown for illustration. Two argon lines (405 nm, 453 nm) recorded by a spectrometer with plane-parallel light-splitter are shown for comparison. Figures 3; references 6: 5 Russian, 1 Western. [271-2415]

UDC 662.997:537.22(088.8)

#### GEOMETRICAL PARAMETERS OF PRISMATIC CONCENTRATORS FOR SOLAR POWER PLANTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 10 Jan 84) pp 20-22

YERMOLOVA, N. G., BRASLAVSKAYA, M. V. and BARANOV, V. K.

[Abstract] Prismatic concentrators are mounted in solar power plants for achieving radiant flux densities comparable with or even exceeding irradiance of the sun. For design analysis of such prismatic components, which requires determining the path of two principal light rays through them, their geometrical parameters are established taking into account that the inclination angle of sun rays to the horizontal prism base varies. The principal parameters determining the prism performance are its base angle, radiation incidence and refraction angles at the optical prism aperture, refractive index of the prism material and critical angle of total reflection, and range of inclination angles of collectible sun rays. The relations between these parameters, particularly dependence of the

normalized dimension of the active prism segment on the inclination angle of a collectible sun ray and dependence of that angle on the prism base angle, are established for two upright mounted prisms with vertical cross section in the form of an isosceles triangle and a right triangle respectively. Included in the calculations are reflections of sun rays by the prism facets and the maximum number of such reflections in each prism. The operative aperture decreases and some vignetting will occur as the inclination angle of sun rays increases up to the lower limit of the range for the forward component, and all the prism aperture will become operative as the inclination angle increases beyond that limit. Figures 3; references 5:  
1 Russian, 4 Western.  
[271-2415]

UDC 621.383.45

COMPARISON OF EQUAL-SIGNAL METHOD AND EQUAL-ENERGY METHOD USED FOR MEASURING CERTAIN PARAMETERS OF NONLINEAR PHOTORECEIVERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 29 Dec 83) pp 44-47

DOLGANIN, Yu. N., KURIKHIN, O. V. and KOVALENKO, K. S.

[Abstract] Two methods are used for measuring photoelectric parameters of nonlinear photoreceivers in exposure meters. The equal-signal method involves estimating any changes in the exposure meter readings, whatever their cause, on the basis of corresponding optical quantities at a fixed photoreceiver response level. The equal-energy method involves recording changes in the photoreceiver response under changing external conditions while maintaining a fixed photoreceiver illuminance. The two methods are evaluated here comparatively, in measuring the temperature coefficient of the photocurrent and the spectral coefficient of perception for CdS photoresistors. The comparison is made by juxtaposing the values of these parameters obtained by each method separately at various nonlinearity levels of the photoresistor energy characteristic, the nonlinearity level having been set for each measurement by the magnitude of the load resistance. Measurements were made on fifty FPF-7 photoresistors, and the readings have been processed into histograms. A statistical analysis of the results reveals that the equal-energy method does not yield the same values of these two parameters under different conditions of measurement, while their values obtained by the equal-signal method do not depend on the nonlinearity of the energy characteristic. Dependence of the measurement error on the magnitude of a parameter, specifically the temperature coefficient of the photocurrent, can be eliminated in the equal-signal method but not in the equal-energy method. Using only the equal-signal method is, therefore, recommended for standardizing the quality control of exposure meters and their photoreceivers. Tables 3; references:  
5 Russian.  
[271-2415]

## INFLUENCE OF SURFACE ERRORS OF OPTICAL PARTS ON SPREAD FUNCTION OF SELECTIVE-INTERFERENCE SPECTROMETERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 16 Feb 84) pp 5-6

GERSHIN, M. A.

[Abstract] The influence of surface defects most commonly encountered in working optical parts on the spread function of selective-interference spectrometers is investigated. The spread functions of spectrometers employing autocollimation and reverse circular schemes are computed. The plots of the spread functions show that the intensity of the functions drops at the peak as the error increases, and that the side peaks also increase. The relationships derived can be used to define the tolerances for fabricating the interference optical parts of spectrometers as a function of the acceptable distortions of the spread functions.

Figures 3; references 4: 2 Russian, 2 Western.

[301-6900]

## INVESTIGATION OF HOLOGRAM ANALYZER WITH SINGLE-COMPONENT OPTICAL HOLOGRAM MATCHING SYSTEM

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 17 Apr 85) pp 8-10

MUSTAFINA, L. T., KUTIKOVA, N. P. and FRANTSUZOVA, N. B.

[Abstract] A hologram analyzer is examined in which variable magnification of the image is achieved by placing the holograms in matched planes at close to twice the focal length of the single-component optical system. The analyzer is made up of a light source, a rotating diffuser, a focusing lens, two holograms, a spatial filter, a matching lens, a receiving lens, a diaphragm, and the photographic film. The system permits arbitrary orientation of the interference bands with minimum distortions of the interacting wavefronts. Figures 4; references 7: 4 Russian, 3 Western.

[301-6900]

## SVIREL-M INFRARED FILTER SPECTROPHOTOMETER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 10 May 84) pp 18-20

LEVASHENKO, G. I., MAZAEV, N. V., NEMCHENKO, V. A. and ROMANCHUK, T. I.

[Abstract] The improved Svirel-M infrared filter spectrophotometer is described. The instrument provides calibration of the channel used to measure the spectral density of the radiation brightness, and eliminates the electrical signal from the source lamp over the measurement channel. The modulation frequency of the radiation from the lamp is increased, and measurements can be made in the horizontal as well as vertical planes. A device is provided for adjusting the lamp and receiver unit visually along their common optical axis. The electrical circuit of the measurement channels, as well as the construction of the optical-mechanical and electronic units, has been approved. The instrument is designed for determining the content and temperatures of individual components of gaseous and two-phase media by simultaneously measuring the spectral coefficient of transmission and spectral energy brightness density of the radiation of the investigated medium in the characteristic zones of radiation of molecular gases and condensate particles in the 0.5-5.5  $\mu\text{m}$  region.

Figures 4; references: 3 Russian.

[301-6900]

## LOW-TEMPERATURE IR RADIATOR

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
pp 20-21

GRIGOREVA, A. F., KURT, V. I., KIATROVA, Z. V. and NOVOSELOV, V. A.

[Abstract] An infrared source is described for reproducing standard energy brightness levels in the 37-250  $\text{W}/(\text{sr}\cdot\text{m}^2)$  band, equivalent to radiation temperatures of 213-343 K. The construction of the device, designated the AChT 213-343/20 K, is examined, and its basic characteristics are presented. The energy brightness reproduction error does not exceed 2% at the  $T = 0.95$  level; the radiation temperature error does not exceed 0.5%.

Figures 3.

[301-6900]



## INFLUENCE OF ROUGHNESS OF ENDS OF FIBER OPTIC PLATES ON MODULATION TRANSFER COEFFICIENT

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 30 May 84) pp 56-57

VASIN, L. I., GUZHEVSKAYA, A. V. and SATTAROV, D. K.

[Abstract] The modulation transfer coefficient is investigated for the series of selected spatial frequencies as a function of the roughness of the treated ends of fiber optic plates. Seven plates prepared from a single block of multiconductor light guides made of KBF10-VT046 glass were investigated. The investigations were performed by finding the modulation transfer coefficient of the polished plates, and comparing that value with the figure found after polishing one of the ends with one of a series of silicon carbide powders. It is found that the modulation transfer coefficient is the same, to within the measurement error, for all of the plates polished on the resin device; felt-polished plates exhibit modulation transfer coefficients coinciding with those of other parts only in the low frequency region; at 25 lines per mm, the coefficient then becomes significantly lower than for any other plates. This indicates that the form of the working end, all other conditions being equal is a determining factor in transmitting the contrast of an image by a fiber optic part. References: 1 Russian.  
[301-6900]

VISUALIZATION OF OPTICAL AXIS OF CO<sub>2</sub> LASER WITH ANNULAR RADIATION BEAM

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 30 May 84) pp 57-58

VORONOV, V. I. and LYAPAKHIN, A. B.

[Abstract] A method is described for visualizing the optical axis of CO<sub>2</sub> lasers producing annular radiation beams. A device implementing the method is described that is based on the ability of the optical prism to reflect input light strictly in parallel as the base is shifted. The method has been tested, and is now in use in the Yupiter 10.6/03 system for vacuum deposition of refractory materials with the help of CW CO<sub>2</sub> laser radiation. Plans call for using the system to adjust the focusing objects in the Yupiter TU installation for cutting and welding various materials. Figures 1; references 5: 3 Russian, 2 Western.  
[301-6900]

## ESTIMATION OF SENSITIVITY OF FIBER OPTIC SENSORS BASED ON IR LIGHT GUIDES OF FLUORIDE AND GERMANATE GLASSES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian, No 4, Apr 85  
pp 60-62

PERMINOVA, V. I. and SYSOEV, V. K.

[Abstract] The sensitivity of polarization and phase fiber optic sensors based on fluoride and germanate light guides is assessed. The analysis indicates that fiber optic light guides made of fluoride and germanate glasses operating in the mid-IR band are promising for use in such physical-field sensors. It is now possible to develop sensors with sensitivity as good as that of devices based on quartz light guides. Figures 2; references 12: 4 Russian, 8 Western.  
[301-6900]

## AUTOMATED SYSTEM FOR MEASURING MODULATION TRANSFER FUNCTION OF LENSES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 11 Jun 84) pp 25-27

GERASIMOV, G. M., SOKOLOVA, N. N. and SHULMAN, M. Ya.

[Abstract] An instrument based on the YuS-105 electronic harmonic analyzer is described that can be used for automatic measurement and recording of the modulation transfer characteristic, or frequency-contrast characteristic, of lenses for a series of spatial frequencies, as well as focusing curves that communicate the relationship between the modulation transfer coefficient and the displacement of the image plane for a given spatial frequency. The structural diagram and schematics of the device are described. The system improved labor productivity in making measurements, records the measurement results objectively, and provides improved accuracy. Provisions are made for connecting a computer to the measurement system. Figures 3; references: 5 Russian.  
[301-6900]

# DEVICE FOR DETERMINING ACCURACY OF MATCH BETWEEN FOCUS OF LENS AND FILM CHANNEL IN SMALL-FORMAT CAMERAS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 6 Aug 84) p 28

KOZIKOV, N. A. and KRASHCHIN, M. D.

[Abstract] A device is described for determining the precision of the match between the focus of the lens and the film channel of small-format cameras that incorporates a mirror-lens reflector. The layout and operation of the device are described. Test results indicate that the standard deviation of a series of measurements is  $\pm 0.015$  mm. The analytical findings indicate that the device can be used to assess the accuracy of match between the focus of the lens in the film channel, as well as the amount of flexure of the film over the entire surface of the frame. The displacement of portions of the film with respect to the focal plane of the lens is determined by moving the camera in the plane perpendicular to the optical axis of the beam of the autocollimator. Figures 1; references: 5 Russian.  
[301-6900]

UDC 539.23:519.237.7

# USE OF MATHEMATICAL STATISTICS TO OPTIMIZE CONDITIONS FOR APPLICATION OF OPTICAL VACUUM COATINGS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 4, Apr 85  
(manuscript received 7 Aug 84) pp 31-34

POVESHCHENKO, V. P., KOSTYUCHENKO, N. G., DEMIDOVICH, T. I.,  
PETLITSKAYA, Ya. V., TROFIKOVA, Dzh. P. and KHOLODOV, V. M.

[Abstract] The use of mathematical experimental design to optimize the technological conditions for obtaining optical coatings of  $ZrO_2$  and  $Al_2O_3$  is described. Factorial experiments are set up and analyzed. It is found, inter alia, that the pressure in the vacuum chamber and the deposition rate have approximately the same influence on the properties of  $ZrO_2$  films. Comparison of the experimental and calculated indexes of refraction shows that the proposed model describes adequately the technological process of applying  $ZrO_2$  and  $Al_2O_3$  films for two variable technological factors. Tables 4; references: 5 Russian.  
[301-6900]

## SHAPING OF ASPHERICAL OPTICAL SURFACES BY "MASK" INSTRUMENT

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian, No 4, Apr 85  
(manuscript received 21 Jun 84) pp 34-36

KHOKHLENKOV, L. N., LYSYANNYJ, Yu. K., and YANUT, Ye. N.

[Abstract] This study describes the development of a stabilized fabrication process for shaping optical parts with aspherical surfaces having slight asphericity (of approximately  $10\ \mu\text{m}$ ) using a "mask" during the polishing process by taking the asphericity allowance once. A recursive formula is derived for defining the  $i$ -th "mask" that measures the theoretical allowance  $H_1$  to within the random errors of the process. The use of the proposed method in polishing an Era-18 convex aspherical lens is described. The results confirm the possibility of using the "mask" method to produce aspherical optical parts on commercially produced type ShP equipment. Figures 3; references: 5 Russian.  
[301-6900]

## GENERATION OF ELECTROMAGNETIC RADIATION IN RADIO-FREQUENCY BAND IN SOLIDS EXPOSED TO LASER RADIATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA Vol 49, No 4, Apr 85 pp 773-775

POGREBNIYAK, A. D. and RAKITIN, S. V.

[Abstract] Experiments are described in which RF electromagnetic radiation is generated in single crystals of silicon and gallium arsenide by exposure to 30-nsec pulses from a Q-switched laser operating at  $\lambda = 694.3\ \text{nm}$ . Each material is found to have a particular threshold in terms of irradiation power density at which electromagnetic radiation pulses begin to be generated. The pulse amplitude increases almost linearly as the power density up to complete mechanical destruction of the specimen. Measurements of electromagnetic radiation in the RF band can be used to judge the stress and defectiveness of crystals, and to obtain certain information about the parameters of the laser radiation. Figures 2; references: 1 Russian.  
[300-6900]

DISPERSION OF p-POLARIZED SURFACE ELECTROMAGNETIC WAVES IN SLIGHTLY  
NONLINEAR THREE-LAYER SYSTEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA Vol 49, No 4,  
Apr 85 pp 806-810

KOCHARYAN, L. M., Yerevan State University

[Abstract] The dispersion formula for p-polarized surface electromagnetic waves in a three-layer system consisting of a thin plate (linear medium) bordering semi-infinite media with slight nonlinearities due to third-order susceptibility is derived. The dispersion formula makes it possible to determine the relationship between the angle of incidence of the radiation that excites surface electromagnetic waves in a three-layer system and the intensity of that radiation. The analytical method, which is based on perturbation theory, cannot be used for s-polarized surface electromagnetic waves in a nonlinear three-layer system because there is no surface s-wave in the zero-order approximation of perturbation theory. The dispersion formula derived describes p-polarized waveguide waves, as well as surface electromagnetic waves. References: 12 Western.  
[300-6900]



UDC 621.396.62.33:621.397.13:629.793

CHANGEOVER OF EKRAN-KR GROUP RECEIVER STATIONS TO MOSKVA RECEPTION SYSTEM

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 2 Aug 84)  
pp 30-34

TUNGUSHBAYEV, A. M., AKHMETOV, Zh. K., SHKUROPAT, V. G. and  
DRIBINSKIY, Ya. L.

[Abstract] In order that the First All-Union television program reach maximum of the population on the territory of the Kazakh SSR, it is necessary that about 1500 Moskva receiver stations operating in the 4 GHz frequency band and approximately as many transmitting relay stations be installed. A part of this requirement could be covered by existing Ekran-KR group receiver stations, but this would require their changeover from present operation in the 700 MHz band to operation in that 4 GHz band. Scientific and technical research has established the theoretical basis for such a changeover, engineering and laboratory experiments having subsequently established the practical feasibility of redesigning the Ekran-KR equipment so as to ensure a performance in the 4 GHz band on par with that of Moskva equipment. This applies specifically to the four main channels affected, microwave channel and intermediate-frequency amplifier channel as well as video channel and sound track. Figures 5; tables 2; references: 4 Russian.  
[308-2415]

UDC 621.396.67

NONDIRECTIONAL ANTENNAS WITH SEVERAL INDEPENDENT INPUTS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 12 Jul 83)  
pp 35-37

TRUSKANOV, D. M. and IVANOV, A. F.

[Abstract] Multiple-input nondirectional antennas for multichannel operation, with neither the structural disadvantage of pyramidal buildup

of several individual antennas nor with the need for tunable decoupling filters, were introduced during the 1971-73 period in the USSR and more recently in other countries. One common example of such an antenna is the turnstile antenna, with two inputs and with its dipoles fed from a quadrature bridge. The transmission coefficient here is 3 dB regardless of which input has been excited, but radial dipoles are not suitable and a major drawback is the strong dependence of the decoupling between inputs on the matching proper of dipoles. Another example is a ring antenna with four inputs, with the array of dipoles fed from four bridges. Various feeder systems and dipole ring configurations have been tested and evaluated for standing-wave ratio and crosstalk attenuation, comparatively with the basic version of a turnstile antenna. Figures 4; tables 3; references 4: 2 Russian, 2 Western. [308-2415]

UDC 621.396.677

#### MEASUREMENT OF LOW REFLECTION COEFFICIENTS

Moscow ELEKTROSVYAZ in Russian No 5, May 85 (manuscript received 29 Mar 84)  
pp 42-43

YAMPOL'SKIY, V. G.

[Abstract] Ensuring a resultant standing-wave ratio of 1.1-1.5 in matched antenna+feeder channels requires that the reflection coefficients at each of the many channel components do not exceed 1-3% and at seals or bends even not 0.5%. Conventional reflectometers are not capable of measuring reflection coefficients below 2-3% with the necessary accuracy, owing to their nonideal intrinsic matching. This difficulty can be overcome by insertion of a feeder line segment such as waveguide between the test object and the reflectometer, a line at least 2-3 times longer than the electrical length of the reflectometer and ideally matched to the test object so as not to introduce distributed reflections. The validity of this method is based on analysis and evaluation of the resultant reflection coefficient at the reflectometer input throughout the reflectometer tuning range, within which the modulus of the resultant reflection coefficient varies between the sum and the difference of the moduli of the reflectometer and test object reflection coefficients. The method was successfully applied to an RPA-2P-2 antenna operating in the 4 GHz frequency band with partial reflection coefficients along the channel within the 0.3-0.7% range. Figures 3;  
[308-2415]

UDC 523.164.8

VENUS-15, VENUS-16 SYNTHETIC APERTURE RADAR ON VENUS SATELLITE ORBIT

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 28, No 3, Mar 85 (manuscript received 7 Aug 84) pp 259-274

BOGOMOLOV, A. F., ZHERIKHIN, N. V. and SOKHOLOV, G. A., Special Design  
Office, Moscow Power Engineering Institute

[Abstract] The principles of the radar survey of the Venus surface made by the Venus-15 and Venus-16 missions are described. Basic technical data for the Polyus-V2 synthetic aperture radar on board the Venus-15 and Venus-16 are given in a table. A photograph is shown of the instrumental container with the antenna system mounted on it. The construction is described of the radar displays and the means and order of data processing by the ground-based stations are discussed. Radar pictures of the Venus surface and altitude profiles are shown. Information was obtained on approximately 115 million km<sup>2</sup> of the northern hemisphere of Venus and surface images of almost optical quality make it possible to begin mapping of the planet. Figures 10; references 8: 2 Russian, 6 non-Russian.  
[256-6415]

UDC 621.317; 621.396.167

ABSOLUTE MEASUREMENTS OF ANTENNA PARAMETERS BY ILLUMINATION METHOD

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 28, No 3, Mar 85 (manuscript received 27 Dec 83) pp 275-282

PELYUSHENKO, S. A., Scientific-Research Radiophysics Institute

[Abstract] At present, optimum precision during absolute radio-astronomical measurements of cosmic radiation intensity, and during calculation of the gain of antennas is attained by use of the "black" disk method, also known as the "artificial moon" method, which was developed at the Gorkiy Scientific-Research Radiophysics Institute (SRRI) in 1960, and successfully used during absolute measurements of millimeter and decimeter waves. The present paper describes a new method for absolute

calibration of antenna gain which uses a metal disk located in the far field of the antenna, which reflects the wideband noise signal radiated by the antenna as the calibrated "transmitter." A block diagram is shown of the radiometer and the antenna-feeder sections. The results of measurements of the effective area of the RTN-7 radio telescope at  $\lambda = 95$  cm agree well with data from the simultaneous calibration of the RTN-7 by the "black" disk method. Graphs are presented of the dependence of the signal-to-noise ratio on the magnitude of the signal illumination during matching of the feed. A diagram is shown of the directivity of the RTN-7 radio telescope in an azimuthal plane. The new method can also be used to measure the radiating power of antennas. The measurements described were made in August-September 1983 at the radio-astronomical station "Staroya Pustyn" of the SRRI. The author thanks N. M. Tseytlin for helpful comments and N. A. Dugin for assistance in conducting measurements. Figures 4; tables 1; references: 6 Russian. [256-6415]

UDC 537.86:519.2

#### QUASI-OPTIMUM DETECTION OF EXTENDED SOURCE OF RANDOM FIELD IN FRESNEL ZONE OF RECEIVING ANTENNA

Gorkiy IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 28, No 3, Mar 85 (manuscript received 20 Feb 84) pp 330-336

KREMER, I. Ya., KASTYLEV, V. I. and POTAPOV, N. A., Voronezhskiy State University

[Abstract] The paper is concerned with the synthesis and analysis of the effectiveness of a quasi-optimum algorithm for detection of an extended source of a random electromagnetic field on a background of the natural noise of a receiving device. It is assumed that the coordinates of the center of the radiation source are unknown, and the general case is considered where the source can be found both in the far zone and in the Fresnel zone of the receiving antenna system. The following are examined: 1) Model of useful signal; 2) Processing system; and 3) Characteristics of detection. Figures 3; references 5: 3 Russian, 2 Western (1 in Russian translation). [256-6415]

## ALGORITHMS OF SIGNAL PROCESSING IN ADAPTIVE ANTENNA ARRAYS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85

(manuscript received, after revision, 30 Aug 84) pp 13-16

RGDIMOV, A. P., GLUSHANKOV, Ye. I. and DAVYDENKO, V. V.

[Abstract] Three algorithms of interference suppression by automatic control of the radiation pattern are considered for space-time processing of signals in adaptive antenna arrays. The first of them is the Widrow-Hopf algorithm, based on steepest descent and instantaneous estimations of the gradient of the mean-square deviation of the output signal from the reference signal. The second algorithm is recurrent direct inversion of the sample covariance matrix of interference, based on the criterion of maximum output signal-to-noise ratio. The third algorithm is Kalman filtration for estimation of the weight vector, essentially generalizing the Widrow-Hopf equation. These three algorithms are evaluated comparatively with respect to efficiency and convergence, also with respect to the number of additions and subtractions, the number of multiplications and divisions, and thus with respect to the memory volume requirement for two typical antenna arrays with  $L = 2$  and  $L = 32$  elements respectively. Numerical calculations indicate that Kalman filtration is most expedient for real-time processing with strong interference suppression and direct matrix inversion algorithms are most expedient under severe size-mass and energy constraints. Gradiental algorithms become expedient only with special means of accelerating their slow convergence. Figures 2; tables 3; references 11: 6 Russian, 5 Western (1 in Russian translation). [259-2415]

UDC 621.396.96

## TIME CHARACTERISTICS OF SCATTERING BY RADAR TARGETS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85

(manuscript received, after revision, 3 Jul 84) pp 16-19

KIRMASOV, V. I.

[Abstract] The time characteristics of scattering by a radar target, which carry information about its shape and size, are calculated by a simple method using the response to a ramp signal as the characteristic of a reflected signal. The feasibility of synthesizing a three-dimensional image of a target from measurements of ramp functions has already been established theoretically and confirmed experimentally. Here the approximation of physical optics is proposed, instead of the Rayleigh theory or the geometric theory of diffraction. Accordingly, a ramp function is evaluated from its



geometry within a given frequency range of probing signals and the fore-shortening. The total effective scattering surface is calculated, as the sum of a monostatic one and a complex-conjugate antipodal monostatic one, with the aid of a Fourier transformation and subsequent inverse Fourier transformation including a change from space coordinate to time on the basis of a constant velocity. Calculations according to this procedure reveal that the approximation of physical optics is accurate only up to the shadow boundary and that a ramp function is adequate for signal wavelengths within the  $0.5L \leq \lambda \leq 5L$  range ( $L$  - largest dimension of target). The method was tested experimentally on a simple conical metal target (length 5 cm, base diameter 1.250 cm) and on a compound cylindrical metal target (total length of two adjacent cylinders 5 cm, ratio of their diameters 2:1). Other approximations are required for targets of nonelementary shapes and with nonideal properties. Figures 2; references: 11 Western. [259-2415]

UDC 621.391.677

#### NOISE FACTOR IN SCANNING ACTIVE PHASED ANTENNA ARRAYS

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after abridgment, 3 Apr 84) pp 57-59

BABENKO, A. I., ZAYTSEV, E. F. and NIKOLAYEVSKIY, A. L.

[Abstract] The noise factor in scanning active antenna arrays is calculated, considering a generally two-dimensional array of lossless radiators with a phasing system and a summing system. Into account are taken coupling between radiators, which causes the output noise as well as the efficiency to vary during a scan, and mismatch between radiators and feeder. This mismatch is characterized by a reflection coefficient  $G(\theta, \phi)$  dependent on the angular coordinates  $\theta, \phi$  of the antenna beam in the "00" feeder section. Analysis of the problem is based on two equivalent noise generators, one on the source side and one on the load side. Calculations require only amplifier "nameplate" noise data, the input reflection coefficient  $S_{11}$  but no other S-parameters of the amplifier, and three temperatures: relative equivalent input noise temperature  $T_1$ , relative equivalent internal amplifier noise temperature  $T_2$ , and temperature  $T_{12}$  characterizing the degree of correlation between the voltages of the two equivalent noise generators. The calculations yield a maximum noise factor  $F_{A, \max} = 1 + (T_2 + T_1 |G|^2 + 2|T_{12}| |G|) / (1 - |G|^2)$  when the relation between  $T_{12}$  and  $G$  is "least" favorable and a minimum noise factor  $F_{A, \min} = 1 + (T_1 + T_1 |G|^2 + 2|T_{12}| |G|^2) / (1 - |G|^2)$  when that relation is "most" favorable. The theoretical results have been verified experimentally on a commercial decimetric-wave amplifier built with bipolar silicon transistors. Figures 2; references 9: 8 Russian, 1 Western. [259-2415]

## PREDICTING WAVEGUIDE PROPAGATION OF RADIO WAVES

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received 5 May 84) pp 59-61

SHLIONSKIY, A. G.

[Abstract] The analytical method of parametric extrema facilitates determination of many characteristics of radio waves on the basis of predictable key ionosphere parameters. This method can be used for predicting the ultimately maximum frequencies of radio waves propagating over a given channel which will not depend on the energy characteristics of these waves and then ensuring the necessary physical conditions at both ends of the channel. Cutoff frequencies for waveguide modes, jump modes and hybrid modes are taken to be the respective lowest frequencies of channel degeneracy to a zero volume along the entire propagation path through a horizontally nonhomogeneous medium. These frequencies depend on the maximum vertical gradient of electron concentration and thus on the principal maximum and minimum of this gradient within the F-layer and within the interlayer valley respectively. In order to predict waveguide propagation and its cutoff frequency, therefore, it is necessary to evaluate the parameters of these two principal extrema. For this is needed the layer altitude above the earth surface, the plasma frequencies of both F-layer and interlayer valley, the layer half-thickness, and the radius of the earth. Semi-empirical formulas for the altitudes and the plasma frequencies of both F-layer and interlayer valley are available, and charts of ultimately maximum frequencies and of maximum usable frequencies have been plotted for this purpose. Figures 1; references: 5 Russian. [259-2415]

UDC 621.372.8.09

## CYLINDRICAL GUIDED WAVES IN SPHENOIDAL WAVEGUIDE

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85  
(manuscript received, after revision, 21 Aug 84) pp 62-64

MITROKHIN, V. N.

[Abstract] Expressions for the parameters of cylindrical guided waves and the equivalent surface currents in a sphenoidal waveguide are derived from expressions for the electromagnetic field components  $E_y$ ,  $H_0$ ,  $H_z$  of natural modes in such a waveguide, in the corresponding system of cylindrical coordinates, taking into consideration that wedge segments of such waveguides are used as reflectors in corner antennas or as artificial reflectors for navigation radar. An analysis of these relations reveals that there

exists a specific caustic surface for each natural electric mode  $E_{m0}$  in such a waveguide, the density of the equivalent electric surface current on it being inversely proportional to the distance from that surface to a critical waveguide section. Attenuation in a lossless waveguide is caused by curvature of the wavefront. The attenuation coefficient and the characteristic impedance have discontinuities at a critical section, the characteristic impedance as well as the propagation "constant" becoming complex quantities beyond it, while the phase "constant" has a finite nonzero value at a critical section. Figures 3; references: 7 Russian.  
[259-2415]

UDC 621.396.43

#### DIFFRACTIVE RELAYING OF RADIO WAVES OVER INTERCEPTED ROUTES

Moscow RADIOTEKHNIKA in Russian No 3, Mar 85 pp 73-74

[Annotation of article No 404 deposited at Central Institute of Scientific and Technical Information 'Informsvyaz', 10 pp with 7 figures and 6 bibliographic references]

DAGUROV, P. N. and CHIMITDORZHIYEV, N. B.

[Abstract] The effect of diffraction on passive relaying of radio waves is evaluated by analysis of forward transmission over a route with intercepting hill or mountain and a tower carrying a transparent plane diffractor shield on top. Intensity and phase of the resultant electric field, including its scattered component, within the Fresnel region of the interceptor are calculated from the geometry of the problem for a typically annular diffractor-relay. The relations become unwieldy in the case of enclosed routes, owing to a more intricate structure of the primary diffraction field and the effect of many random factors. In this case, especially, optimization of the diffractor-relay design and of the operating conditions must be based on experimental data, most important being the dependence of signal level on gap width between hill crest and diffractor shield for direct passage of radio waves. Figures 1; references: 2 Russian.  
[259-2415]

## OPTIMIZATION OF ANTENNA FORMED BY ELECTROSTATIC FORCES

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA  
in Russian No 4, Apr 85 pp 5-10

STADNIK, I. P., MILYUKOV, V. V., KOSHELEV, V. A., CHEREDNICHENKO, I. I.  
and KULIKOV, S. P.

[Abstract] This study addresses the analysis of electrostatically formed antennas in order to optimize the choice of the number and location of controlled electrodes, as well as the voltages between the electrodes and the membrane, in order to create the required pressure. An optimization algorithm is proposed for an antenna formed by an electrical field with the shape of the electrode region fixed. A uniquely solvable system of integral equations for the charge density is derived. The integral equation for the distribution of the electrostatic pressure over the membrane is solved for the example of a spherical segment. Figures 3; references 5: 3 Russian, 2 Western.  
[289-6900]

UDC 621.396.67.01

## DIRECTIVITY OF ANTENNA IN LOSSY MEDIUM

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 14 Aug 84) pp 427-433

FELD, Ya. N.

[Abstract] The directive gain of an antenna in a lossy medium is determined, considering an antenna which can operate in both transmitter and receiver modes. The maximum directive gain in such a medium has already been shown to be finite, even without some additional constraint usually required to ensure a finite directivity. Calculations are made with the aid of an auxiliary dipole with unit moment at the observation point. The results for the one-dimensional problem of a straight wire yield not only the directivity of the latter but then also the optimum distribution of the tangential electric-field component. The two-dimensional problem of a cylinder with arbitrary cross-section, infinitely long and thus the axial coordinate eliminated as argument, is solved on the basis of the Cauchy-Bunyakovskiy inequality and the homogeneous Helmholtz equation. The solution yields fast converging series for the directivity and the optimum electric field respectively. In the ideal lossless case both series become divergent and the directivity becomes infinite. The author thanks M. S. Agranovich for assistance with the two-dimensional problem. Figures 1; references: 5 Russian.  
[307-2415]



## EFFECTIVENESS OF PHASE-CONJUGATION SYSTEMS IN TURBULENT ATMOSPHERE

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 26 Oct 83) pp 463-469

POLOVINKIN, A. V. and SAICHEV, A. I.

[Abstract] The performance of phase-conjugation adaptive systems for ranging and probing is analyzed, taking into account turbulence of the real atmosphere. Specifically, a system is considered which reverses only the front of the incident waves, and builds up the reflected wave to an amplitude not dependent on that of the incident wave. The mean field intensity and the mean energy of reflected waves are calculated in the Gaussian approximation, with an attendant evaluation of their statistical characteristics, assuming that a spherical wave from a point source is reflected by such a phase-conjugation system at a given distance  $L$  away and that the amplitude of the reflected wave is known. General relations are established and applied to reflectors with small aperture  $d < \rho_c$  and correspondingly strong diffraction, to reflectors with apertures within the intermediate  $\rho_c < d < \sigma_\phi$  range, and to reflectors with large apertures with compensation  $d > \sigma_\phi$  and strong refraction ( $\rho_c$  - coherence radius of wave after passage of distance  $L$  through turbulent atmosphere,  $\sigma_\phi = L/k\rho_c$  - fluctuation saturation radius,  $k$  - wave number). In the case of large aperture the mean intensity of the reflected field is almost the same in a turbulent medium as in a homogeneous one. In both large and small apertures the mean intensity is equal to the intensity at the center, owing to the particular mechanism operating in each case. In the case of small apertures, moreover, absence of backscattering because of suppression of amplitude fluctuations reduces the intensity of the reflected wave to only half the intensity of a wave reflected by a wavefront reversing mirror. Therefore, phase-conjugation systems with small reflector aperture are not particularly advantageous. Figures 1; references 12: 9 Russian, 3 Western (1 in Russian translation).

[307-2415]

UDC 621.396.677:537.8

## ELECTRODYNAMIC MODEL OF RECEIVER ANTENNA

Moscow RADIOTEKHNIKA I ELEKTRONIKA in Russian Vol 30, No 3, Mar 85  
(manuscript received 23 Sep 83) pp 470-475

MARTSAFEY, V. V. and TSALIMOV, G. F.

[Abstract] An electrodynamic model of a receiver antenna is constructed which correctly describes the load, a crucial element, without requiring the



reciprocity theorem and thus applicable also to nonlinear or anisotropic antenna materials. A load inside a regular waveguide, as in horn antennas and refractor or reflector antennas with horn-waveguide exciter, is considered for specificity. As antenna is selected the open end of a plane waveguide of finite length. The antenna radiation pattern and scattering pattern as well as the antenna currents are calculated by the method of replacing the load with an equivalent source. The corresponding problem of diffraction is solved by the numerical method of Ya. N. Feld, involving reduction to a system of equations in scalar products of currents on the waveguide contour and the voltages induced by them in the waveguide contour, with a weight function which ensures that Maxwell conditions are satisfied at points on the contour. Figures 5; references 11: 8 Russian, 3 Western (2 in Russian translation).  
[307-2415]

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